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WYCAR 3.3

Pacific Sound Resources (PSR)
Superfund Site
Seattle, Washington

Record of Decision

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LIST OF ACRONYMS AND ABBREVIATIONS

ACL	Alternate Concentration Limit
AET	Apparent Effects Threshold
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
B(a)P	Benzo(a)pyrene
CAD	Confined Aquatic Disposal
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulation
CMS	Crowley Marine Services
CND	Confined Nearshore Disposal
COC	Chemical of Concern
CSF	Cancer Slope Factor
CSL	Cleanup Screening Level
CSO	Combined Sewer Overflow
CWA	Clean Water Act
cy	cubic yards
DMMP	Dredged Material Management Program
DNAPL	Dense Non-Aqueous Phase Liquid
DNR	Washington State Department of Natural Resources
DRET	Dredge Elutriate Test
Ecology	Washington State Department of Ecology
EP	Eddy Pump
EPA	U.S. Environmental Protection Agency
ETI	Environmental Toxicology International
FS	Feasibility Study
HI	Hazard Index
HPAH	High Molecular Weight Polycyclic Aromatic Hydrocarbon
HQ	Hazard Quotient
I&M	Inspection and Maintenance
IRIS	Integrated Risk Information System
LAET	Lowest Apparent Effects Threshold
2LAET	Second-Lowest Apparent Effects Threshold
LNAPL	Light Non-Aqueous Phase Liquid

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

LPAH	Low Molecular Weight Polycyclic Aromatic Hydrocarbon
MCL	Maximum Contaminant Level
MCUL	Minimum Cleanup Standard
MET	Modified Elutriate Test
MLLW	Mean Lower Low Water
MTCA	Model Toxics Control Act
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
O&M	Operation and Maintenance
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PSDDA	Puget Sound Dredged Disposal Analysis
PSR	Pacific Sound Resources
PSR MSU	Pacific Sound Resources Marine Sediments Unit
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RETEC	Remediation Technologies, Inc.
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximally Exposed
ROD	Record of Decision
ROV	Remotely Operated Vehicle
SMS	Sediment Management Standards
SQS	Sediment Quality Standard
SVPS	Sediment Vertical Profiling System
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-tetrachlorodibenzo-furan
TEF	Toxicity Equivalency Factor
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSDF	Treatment, Storage, and Disposal Facility

LIST OF ACRONYMS AND ABBREVIATIONS *(Continued)*

USGS	U.S. Geological Survey
WES	Waterway Experiment Station

PART 1: THE DECLARATION

Site Name and Location

The Pacific Sound Resources (PSR) facility, formerly known as the Wyckoff West Seattle Wood Treating facility, was located on the south shore of Elliott Bay in Puget Sound at 2801 S.W. Florida Street, Seattle, Washington. The Environmental Protection Agency (EPA) identification number is WAD009248287.

The site was divided into two operable units for investigation purposes; the Upland Unit and the Marine Sediments Unit. This Record of Decision (ROD) addresses both Units.

The upland property was purchased by the Port of Seattle (Port) and included in their redevelopment and expansion of an intermodal container terminal facility. The early actions conducted under removal authority were implemented to control the site and prepare it for reuse. The upland site is currently being utilized as part of the Port's intermodal yard.

Statement of Basis and Purpose

This decision document presents the Selected Remedy for the PSR site, which was chosen in accordance with Comprehensive Environmental Response Compensation and Liability Act (CERCLA), as amended, and to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record file for this site.

The State of Washington Department of Ecology concurs with the Selected Remedy.

Assessment of Site

The response action selected in this ROD is necessary to protect the public health and welfare, and the environment from imminent and substantial endangerment from actual or threatened releases of hazardous substances into the environment.

Description of Selected Remedy

Upland Unit

The cleanup actions that have been completed to date include demolition of all on-site structures, source material removal (highly contaminated soil and sludge), non-aqueous phase liquid (NAPL) collection and disposal, and isolation of remaining contaminated soil and groundwater with a low-permeability surface cap and subsurface slurry wall. These cleanup actions have addressed the contaminated soil and on-going sources to the off-shore marine environment. What was selected as early action is final action with the addition of the following:

- Inspection and Maintenance (I&M) of the surface cap
- Monitoring groundwater and collection of NAPL
- Institutional controls for prohibiting groundwater use and restricting land use

Marine Sediments Unit

The Selected Remedy for the Marine Sediments Unit is:

- Confinement through capping of contaminated marine sediments
- Five feet of clean cap material will be placed in the intertidal area
- Dredging of approximately 3,500 cubic yards of contaminated sediment to maintain navigational access
- Unused pilings will be removed
- Institutional controls to prohibit large anchor use in capped area
- Monitoring cap placement and cap performance

Statutory Determinations

The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost-effective. Treatment was evaluated for sediment cleanup, however was not considered further for the following reasons: 1) there are currently no effective *in situ* treatments (i.e., treating in place) for sediments covering a large area and subjected to significant flushing, and 2) any *ex situ* treatment would require significant material handling (excavation, dewatering, transport, and processing) and extreme cost (estimated at \$40 million excluding material handling). Thus, the Selected Remedy does not satisfy the statutory preference for treatment as a principal element. Because this remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a review will be conducted within five years after initiation of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.


Data Certification Checklist

The following information is included in the *Decision Summary* section of this ROD. Additional information can be found in the Administrative Record file for this site.

- Chemicals of concern and their respective concentrations (see Tables 7 and 8)
- Baseline risk represented by the chemicals of concern (see Section 7.2.4, Human Health Risk Characterization)
- Cleanup levels established for chemicals of concern and basis for the levels (see Table 5)

- How source materials constituting principal threats are addressed (see Section 9.1.1, Completed Early Actions)
- Current and reasonable anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (see Section 6, Current and Potential Future Site and Resource Uses)
- Potential land and groundwater use that will be available at the site as a result of the Selected Remedy (see Section 11.1, Upland Unit Selected Remedy)
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs; discount rate; and the number of years over which the remedy cost estimates are projected (see Tables 28 and 29)
- Key factors that led to selecting the remedy (see Section 10, Comparative Analysis of Alternatives)

Authorizing Signature



Chuck Clarke
Regional Administrator

9/30/99
Date

PART 2: THE DECISION SUMMARY

1. SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The Pacific Sound Resources (PSR) facility, formerly known as the Wyckoff West Seattle Wood Treating facility, was located on the south shore of Elliott Bay in Puget Sound at 2801 S.W. Florida Street, Seattle, Washington (see Figure 1). Wood-treating operations were conducted at the site from 1909 to 1994. The wood-treating facility occupied approximately 25 upland acres. The southern portion of the facility (10 acres) was used primarily for treated wood storage, and the northern portion of the facility (15 acres) was used for processing. All retorts, product storage tanks and piping were located on the northern portion of the facility. The wood-treating chemicals used at the PSR site included creosote, pentachlorophenol, and various metals-based solutions. Soil, groundwater and off-shore marine sediments have all been impacted by the facility's operation.

EPA is the lead agency for this site and the Washington State Department of Ecology (Ecology) is the support agency involved. There are two sources of funding for cleanup of this site; one is monies from a settlement involving the shareholders of the PSR Company (referred to hereafter as the Company) in which an environmental trust was created to dedicate all the assets of PSR at the time of the settlement to cleanup costs, and the other source is the Superfund.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Site History

The wood-treating plant started as a pile-supported facility over the Duwamish River estuary. The shoreline and intertidal area was filled in at various times throughout the last 100 years, and the facility was eventually entirely located on fill material that created an upland. This in-filling resulted in the border between the upland and off-shore area being a steep riprap bank. The site is located in an industrial area on the south shore of Elliott Bay.

2.2 Actions to Date

EPA conducted two phases of early cleanup actions on the upland portion of the site. The first phase focused on site stabilization and demolition of on-site structures. The second phase focused on controlling on going sources to Elliott Bay, addressing contaminated soil, and preparing the site for reuse by the Port of Seattle (Port). During the first phase, in 1995, the entire wood treatment facility was demolished and approximately 4,000 cubic yards of highly contaminated soil and process sludge were removed from the site. During the second phase, which began in 1996, a subsurface physical containment barrier (slurry wall) was installed to prevent light non-aqueous phase liquid (LNAPL) migration to Elliott Bay, and to reduce the influence of tidal fluctuation at the site. The slurry wall is 1,200 feet in length and it extends from the ground surface to a depth that averages 40 feet below ground surface. An LNAPL recovery trench was installed in conjunction with the barrier wall to intercept any LNAPL. In

addition, a low-permeability asphalt cap was constructed over a layer of clean fill placed at the site. This cap was designed to prevent direct soil exposure to on-site workers, prevent runoff of contaminated soil to Elliott Bay, and minimize infiltration of storm water to groundwater. The cap was completed in 1998.

Other early actions taken at the site include clean out of the Longfellow Creek overflow channel and marine outfall (along the western border of the site - see Figure 2), and collection and disposal of the dense non-aqueous phase liquid (DNAPL) that accumulates in on-site monitoring wells. Twenty-five cubic yards of PCB contaminated sediments were removed from the Longfellow Creek outfall area by the Port as part of their terminal development work, and approximately 1,500 gallons of DNAPL has been recovered from on-site wells and treated through incineration over the last three years.

2.3 Investigation History

Numerous investigations were conducted at this site prior to the initiation of the RI/FS. The Wyckoff Company, EPA, and Ecology all investigated various aspects of the site between 1983 and 1992 under regulatory authority other than Comprehensive Environmental Response Compensation and Liability Act (CERCLA). While work was conducted under Resource Recovery and Conservation Act (RCRA) authority, the site was not considered a treatment, storage and disposal facility (TSDF). Company relations with EPA and Ecology were contentious through the 1980s, and included a federal criminal prosecution for violations of the Clean Water Act and RCRA.

The Upland Unit RI/FS began in 1994 and focused on groundwater, including non-aqueous phase liquid (NAPL) contamination. The Marine Sediments Unit RI/FS began in 1996 and focused on marine sediment contamination. Human health and ecological risk assessments were conducted for both the upland and off-shore areas.

2.4 Enforcement History

The PSR site was added to the National Priorities List in May 1994. A settlement with the Company was embodied in a Consent Decree entered in Federal District Court in August 1994. The Decree creates the PSR Environmental Trust into which the heirs of the Wyckoff Company founders, owners and operators placed all ownership rights and shares in the Company to allow the Trust to maximize liquidation of all company assets, including nonwood-treating holdings, for the benefit of the environment. The beneficiaries of the Trust are the United States Department of Interior, National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, and the Suquamish and Muckleshoot Tribes, as Natural Resource Trustees, as well as EPA for reimbursement of CERCLA remedial costs.

3. COMMUNITY PARTICIPATION

EPA, Ecology, and the Port have kept the public aware and updated with respect to cleanup and redevelopment progress at the site. Community participation in this process has included personal interviews, public signs, fact sheets, newspaper notices, and public comment on

previous cleanup actions. In addition, the Port has worked extensively with the local community regarding its redevelopment project to address traffic, lighting, noise, and public access concerns.

The RI/FS reports and Proposed Plan for the PSR site were made available to the public in April 1999. They can be found in the Administrative Record file that is maintained at the U.S. EPA Records Center on the seventh floor of 1200 Sixth Avenue in Seattle. The notice of the availability of these two documents was published in the Seattle Times on April 21, 1999. A public comment period was held from April 15 to May 15, 1999. EPA's response to comments received during this period is included in the Responsiveness Summary, which is part of this Record of Decision (ROD).

4. SCOPE AND ROLE OF RESPONSE ACTION

The cleanup actions previously completed at this site removed the ongoing source of subsurface contamination and the highly contaminated material (soil and sludge) above the water table that was the source of increasing contaminant volume in the subsurface and the primary driver for contaminant migration. These actions also eliminated the threat of contact with contaminated soil through construction of a barrier, and reduced contaminated groundwater impacts to Elliott Bay through placement of a subsurface wall. While contamination will remain on-site, its potential to adversely impact human health and the environment has been mitigated by isolating it and stopping its continued migration.

The PSR facility did not identify itself as a Treatment, Storage and Disposal Facility (TSDF) pursuant to the RCRA procedures while it was operating. No determination was made through a compliance action that the wood-treating operation was a TSDF. As such, the facility was not subject to RCRA storage closure requirements. However, the facility was identified as a hazardous waste generator (Resource Conservation and Recovery Identification System number WAD009248287), and wastes taken from the site as part of the removal actions were sent to a RCRA-permitted land disposal facility. The Land Disposal Restriction treatment standards had not been established for wood-treating waste at the time the removal actions were conducted.

The groundwater investigation indicates that groundwater does contain site-related contaminants, however the concentration in groundwater at the point where it enters Elliott Bay (the sediment/surface water interface or "mudline") is so low that it is not a source of contamination to either the bay (surface water) or the marine sediment. While this ROD requires ongoing monitoring of groundwater, inspection and maintenance of the upland cap, and institutional controls for the Upland Unit to assure the efficacy and integrity of previously implemented removals, the Selected Remedy contained herein focuses on contaminated marine sediment.

The Marine Sediments Unit encompasses both intertidal and subtidal areas. The intertidal area is approximately two acres in size and is only emergent during lower tides. Specifically, the subtidal area consists of two beach areas that emerge between the piers. These small beaches are referred to as pocket beaches. In addition, the intertidal area includes a thin beach along the toe of the riprap bank at extremely low tides. The subtidal area ranges in depth

from intertidal to greater than 200 feet, with approximately 35 percent of the area having a slope of 18 to 21 percent.

This ROD contains the final cleanup actions for this site.

5. SITE CHARACTERISTICS

This section summarizes information obtained as part of RI/FS activities at the site. It includes a description of the conceptual site model on which all investigations, the risk assessment, and response actions are based. In addition, this section presents sources of contamination, subsequent sampling strategies, and documented types of contamination and affected media. The conceptual site model is presented for the entire site; all other information is presented by operable unit. Figure 2 depicts current site features.

5.1 Conceptual Site Model

The Conceptual Site Model depicting contaminant migration for the Upland Unit and Marine Sediments Unit of the PSR site is presented in Figure 3. The primary source of contamination in the Upland Unit (soil and groundwater) was the daily operation of the wood-treating facility including spills, leaks and storage of wood-treatment products. Based on soil borings taken from the Upland Unit, it appears that releases of wood-treatment products occurred throughout the facility's lifetime. Borings reveal layers of contamination that indicate releases occurred both before and after the various filling episodes that turned the originally pile-supported facility into an upland area. Due to the nature of the material (primarily creosote and an oil carrier containing other wood-treatment chemicals), the volume of released material increased with time and seeped down into the soil, encountered groundwater, and separated into a light and dense phase. The lighter phase floats on the groundwater and the denser (or heavier) phase sinks through the soil formation. The floating material is referred to as light non-aqueous phase liquid (LNAPL) and the sinking material is referred to as dense non-aqueous phase liquid (DNAPL). The NAPL associated with the PSR site is detected in the environment as polycyclic aromatic hydrocarbons (PAHs). Creosote is primarily made up of PAHs.

The LNAPL followed the flow pathway of the groundwater (i.e., discharged to Elliott Bay). Prior to the placement of the slurry wall, LNAPL was seen as oily seepage at the shoreline of the facility. DNAPL followed the path of least resistance (which is downward, due to gravity; however, the path has a lateral component due to grain size variation). Free-phase NAPL (both light or dense) is mobile and able to flow. Residual NAPL is the material that is left behind after the free-phase NAPL (either light or dense) has moved through (i.e., NAPL caught in the soil pore spaces). NAPL stringers result when the majority of the mass of NAPL had been spent and the remainder continues to "trickle" through the formation. Residual NAPL will often be detected in the form of stringers, indicating that a larger NAPL mass exists in the area. Consequently, in addition to the layers of contamination created by releases to the soil surface both before and after the filling in of the upland area, upland soil borings indicate NAPL contamination as deep as the deepest borings taken (100 feet below ground surface).

Passive NAPL collection trials were conducted during the Upland Unit RI and determined that free-phase NAPL recharge volumes (i.e., how much material flowed back into a well after collection) decreased at all collection locations over time. Since the collection locations were chosen based on soil borings and subsurface detection methods indicating higher concentrations of NAPL, it is determined that free-phase NAPL exists in thin layers or stringers at this site, rather than pools.

Of primary concern when initiating the RI/FS for this site, was whether the contamination associated with the upland facility was the source of the contamination in the marine sediment. Specifically, if the upland facility were the primary source, eliminating or controlling that source would be necessary prior to active sediment remediation. As the RI results indicated and Figure 3 depicts, the source of contamination to the marine sediment is not the upland NAPL, rather it was surface releases of wood-treatment contaminants to the off-shore environment. Off-shore sediment borings indicate a clear demarcation between native material (i.e., a clean estuarine formation) and the contaminated material above it. To distinguish between the native and contaminated material, the contaminated material is referred to as the Marine Sediments Unit Fill Area throughout this ROD. While the borings reveal a surface source of contamination to the Marine Sediments Unit rather than a lateral source, they also reveal stringers of NAPL far below the sediment surface.

Current sediment contamination is the primary result of the following historical releases:

- Releases of used or waste creosote and associated wood preservative carrier oil to surface water from the wood-treatment operations. This release pathway contaminated sediments in the southwestern portion of Elliott Bay and represents the primary source of contamination to the Marine Sediments Unit.
- Releases of process wastewater and contaminated stormwater from the Upland Unit to Elliott Bay. These releases contributed to sediment contamination as a result of the partitioning of dissolved contaminants to sediment.
- Erosion of contaminated soil by surface water runoff to Elliott Bay. This pathway contributed minor amounts of contamination to the marine sediments.
- Historical downward and lateral migration of free-phase creosote and oil via preferential flow pathways (e.g., sand layers in subsurface sediment) towards Elliott Bay. While NAPL migration has been effectively stopped through implementation of early actions, the NAPL that remains in place continues to dissolve into groundwater.

Transport of contaminated groundwater from the Upland Unit to Elliott Bay is an ongoing process, however the concentration of contaminants in groundwater is not resulting in injury to Elliott Bay (i.e., surface water is not being impacted). Installation of the slurry wall near the shoreline has nearly eliminated migration of contaminated shallow groundwater (less than 40 feet below ground surface) to Elliott Bay and completely stopped LNAPL seepage at the shoreline. However, modeling suggests that deeper groundwater may contribute to sediment contamination via dissolved contaminant advection and dispersion (i.e., the slow dissolution of NAPL into groundwater and the consequent movement of groundwater to the sediments of Elliott Bay). Based on modeling results, this could result in recontamination in a specific area of

the Marine Sediments Unit referred to as the Intermediate Groundwater Discharge Zone (see Figure 4). It is important to note that this potential for recontamination is based on modeling that used conservative assumptions and overestimates the amount of contamination that would dissolve in groundwater and later be bound to sediments.

The conceptual site model is primarily based on the interaction of wood-treatment chemicals in the environment. However, the Marine Sediments Unit RI also found PCB contamination from and in the local vicinity of the Longfellow Creek outfall (not from the PSR site). Historically, Longfellow Creek flowed along the western boundary of the site, but was rerouted to discharge to the West Waterway of the Duwamish River. The original creek bed was piped and serves as a stormwater and creek overflow channel. The Longfellow Creek overflow discharges just west of the Upland Unit into the Marine Sediments Unit.

5.2 Upland Unit

5.2.1 Upland Overview

The Upland Unit, consisting of the former wood-treating facility, occupies approximately 25 acres. The Upland Unit is bounded to the north by Elliott Bay and by the Port of Seattle's newly constructed intermodal rail yard and container shipping terminal on all other sides. The West Waterway of the Duwamish River, which discharges to Elliott Bay, borders the terminal to the east. An active bulk materials shipping facility [Crowley Marine Services (CMS)], lies directly west of the container terminal (and the former PSR Upland Unit).

The wood-treating plant evolved over time from a pile-supported facility over water to a facility constructed on fill. The upland site is currently situated on approximately 20 to 45 feet of fill material that was intermittently placed over a 50-year span on what was the Duwamish River estuary. Fill materials generally consist of dredged sediments or excavated soils, sawdust, and construction debris. Wood and concrete bulkheads constructed to contain the fill material, as well as control erosion and protect equipment from marine tides, are still buried beneath the site. No surface water bodies are located within the Upland Unit, although localized flooding had been documented during periods of heavy rainfall at the wood-treating facility.

Currently, the Upland Unit is covered with a low-permeability asphalt cap that includes an underground storm drainage and utility system, railroad tracks, and a maintenance and repair building associated with the intermodal rail yard. The northern-most shoreline was developed as a public viewing area and consists of lawns, landscaping, playscapes, concrete pathways, public rest rooms and outdoor showers, a viewing tower and public access pier. Fencing and fishing exclusion screens border the shoreline and pier and restrict access to the intertidal area..

5.2.2 Upland Sources of Contamination

Early actions at the site removed much of the process-related source materials including leaking storage tanks and 3,840 tons of process sludges and creosote-saturated soils. Material remaining on-site includes contaminated soil and groundwater, limited LNAPL, and widespread DNAPL. Additional actions at the site have contained the majority of the on-site contaminated

media. DNAPL occurs on the site in both free (i.e., mobile) and residual phases. The free-phase DNAPL appears to be distributed throughout the site rather than in discreet accumulations or pools.

Some DNAPL has been measured in the shoreline wells on the western portion of the site. However, continued monitoring of those wells and pumping of all on-site wells containing measurable quantities of NAPL has reduced the occurrence and volume of DNAPL in these wells. DNAPL was also detected at some of the deepest stations sampled under the upland process area (i.e., 100 feet below ground surface) and extends as stringers downward and toward Elliott Bay.

Evaluations made during the RI concluded that the stringers of creosote extending underneath Elliott Bay (approximately 80 feet below the sediment surface) are highly unlikely to seep up and out of the sediment and into Elliott Bay. This conclusion was based, in part, on the characteristics of the underlying stratigraphy (layers of estuarine sediment parallel the sloping bottom surface), and continued gravitational pull (DNAPL does not flow uphill). However, the residual or free-phase DNAPL will contribute to dissolved groundwater contamination as groundwater moves past the DNAPL mass.

The majority of the contamination associated with the Upland Unit has been contained behind and below the barrier wall and cap. The relatively small percentage of NAPL that has not been isolated by the wall and cap can act as a source to groundwater contamination.

5.2.3 Upland Sampling Strategy

The Upland Unit RI/FS began in 1994 and focused on establishing the nature and extent of soil and groundwater contamination and the distribution of non-aqueous phase liquids (NAPLs). Evidence of staining and chemical analyses of soil from over 215 borings were used to establish the extent of contamination in soil and confirm the presence of NAPLs. Numerous groundwater samples were analyzed for chemicals of concern and measurements of NAPL thickness and recovery were made in all affected wells. Tidal studies were conducted to examine the effectiveness of the subsurface wall in minimizing the influence marine water of Elliott Bay on groundwater flows at the site. Geological investigations examined the subsurface stratigraphy and a laser-induced fluorescence sampling device was used to establish areas of free-phase or recoverable DNAPL in the northern portion of the site.

Based on the results of subsurface investigations, recovery wells were installed in the areas of free-phase NAPL accumulations. A test was conducted to determine how much NAPL could be collected by encouraging flow into on-site wells through varying the interval between collection events. *In situ* flushing and biological treatability studies for groundwater were also conducted to determine their effectiveness at the PSR site. In addition, the upland investigation included an assessment of the performance of the barrier wall.

5.2.4 Upland Nature and Extent of Contamination

As stated previously, wood-treating chemicals used at the facility included creosote (primarily composed of PAHs), pentachlorophenol (PCP), and various metal (arsenic, chromium, copper and zinc)-based solutions. Facility operations, including spills, leaks, and storage of wood-treatment products, were primarily responsible for upland soil and groundwater contamination. Based on work prior to the RI (RETEC et al., 1994, **Current Conditions Report**), it was established that the majority of the contamination occurred in the northern portion of the site in areas associated with the wood-processing and treated wood storage areas.

During the RI and prior to placement of the subsurface wall, PAHs were detected in the majority of the wells sampled, including shoreline wells. DNAPLs were found in several wells, including two shoreline well clusters along the western shoreline. The mass of NAPL that may be present beneath the site in both soils and groundwater is estimated at over 12.2 million pounds. About 550,000 lbs. is estimated to be present as free-phase NAPL; the remainder exists as residual NAPL. The majority of the NAPLs occur at depths greater than 8 ft below ground surface (where the groundwater table occurs). The Upland RI/FS estimates that 96 percent of the NAPL associated with the PSR site is either behind or below the subsurface slurry wall.

Groundwater Contamination

The hydrogeology of the Upland Unit is characterized by a single unconfined shallow aquifer within the fill and alluvium. This aquifer, which is contaminated by significant concentrations of creosote constituents in both dissolved and DNAPL forms, has been determined to be non-potable by the Washington State Department of Ecology. EPA's groundwater classification evaluation has resulted in this aquifer being classified as both Class IIb and Class III (see following discussion under Key Applicable or Relevant and Appropriate Requirements).

Groundwater recharge in the area occurs as a result of stormwater infiltration from the site, as well as from upland areas to the south. However, onsite stormwater infiltration has been precluded by the construction of the asphalt cap covering the upland site. Groundwater below the Upland Unit is influenced by infiltration and tidal fluctuation of estuarine waters from Elliott Bay, but these influences have been significantly reduced by the slurry wall.

The overall movement of groundwater in the vicinity of the site is in a northerly direction toward Elliott Bay. Groundwater discharge to the bay occurs via shoreline diffuse flow through nearshore sediments. To evaluate the potential impact of groundwater transport on sediment quality in the Marine Sediments Unit, groundwater fate and transport modeling was conducted as part of both the Upland and Marine Sediments Unit remedial investigations. The results of the upland modeling effort, which focused on water quality at the potential point of discharge, indicates that groundwater meets cleanup goals at the mudline (i.e., the point where groundwater enters Elliott Bay).

For the Marine Sediments Unit modeling effort, BIOSCREEN (an EPA fate and transport model) was used to determine whether the existing groundwater quality conditions have the

potential to contaminate a clean sediment cap following site remediation (i.e., following placement of a 3-foot thick cap over existing contaminated sediment). The BIOSCREEN model results predicted that sediment concentrations for two individual PAHs would exceed 2LAET values after 10 years in the intermediate groundwater discharge zone (-25 to -50 feet MLLW along the west-central shoreline). It was determined that this potential for sediment recontamination is primarily associated with groundwater flowing from the west-central portion of the upland site. However, assumptions used in the model were very conservative and did not account for any natural attenuation that may occur and assumed 100 percent of the contaminant mass transported by groundwater would be retained in the sediments.

5.3 Marine Sediments Unit

5.3.1 Marine Sediments Unit Overview

The investigation of the Marine Sediments Unit encompassed approximately 200 acres of Elliott Bay and 1,600 feet of shoreline adjacent to and offshore of the Upland Unit. The shoreline consists primarily of rock and riprap. Three wooden piers, which form the Main and West slips, extend into the central and western portions of the Marine Sediments Unit. As part of the Port's redevelopment of the site, the western-most pier has been repaired for use as a public viewing platform. The two remaining piers will be removed to facilitate cleanup of the Marine Sediments Unit. Two small pocket beaches exist between the piers and adjacent to Crowley Marine Services; a thin band of a muddy sand beach forms along the toe of the ripped banks on more extreme tides.

Bottom depths within the Marine Sediments Unit vary from intertidal to over 200 feet deep, with a generally steeply sloped configuration ranging from 6 to 20 (or greater) percent slope. The steepest slopes are nearshore, and slopes gradually decrease with increasing distance offshore.

5.3.2 Marine Sediments Unit Sources of Contamination

Sediment contamination in the Marine Sediments Unit is the result of releases of wood-treating preservatives during the treatment and storage process, or release of process wastewater, from the Upland Unit to Elliott Bay. Downward and lateral migration of free-phase NAPLs, transport of contaminated groundwater, and erosion of contaminated soils by stormwater runoff from the Upland Unit represent other historical sources and transport pathways to the Marine Sediments Unit. In addition, the Longfellow Creek outfall contributed PCB contamination to the Marine Sediments Unit, and mercury contamination appears to have migrated from a source to the east of the site.

As a result of cleanup actions in the Upland Unit, there are only three likely contaminant migration pathways remaining: transport of dissolved contaminants via groundwater with subsequent partitioning to sediment, dissolution of sediment-bound contaminants to the waters of Elliott Bay, and longshore or downslope migration of contaminated surface sediment in the Marine Sediments Unit. The transport of free- and dissolved-phase NAPL in shallow groundwater to Elliott Bay has been inhibited by the slurry wall and LNAPL recovery trench that

were constructed as part of the upland source control activities. However, some DNAPL is present seaward of and deeper than the slurry wall, constituting an ongoing, however minor source to the bay. Modeling conducted as part of the Marine Sediments Unit RI suggested that deep groundwater discharging from the western portion of the site may have the potential to recontaminate sediment in the intermediate groundwater discharge zone offshore of Crowley Marine Services. However, assumptions used in the model were very conservative, did not account for any natural attenuation that may occur, and assumed 100 percent of the contaminant mass transported by groundwater would be retained in the sediments.

5.3.3 Marine Sediments Unit Sampling Strategy

The RI sampling activities in the Marine Sediments Unit were conducted in three phases that extended from April 1996 to July 1997 and included the following:

- Subtidal surface and subsurface sediment sampling and chemical and physical analysis to determine the nature and extent of contamination. A limited number of subsurface samples were also analyzed for various engineering parameters to support future design evaluations.
- Fish and shellfish tissue sampling and chemical and physical analysis to evaluate biological uptake and potential fish and human health risks.
- Laboratory bioassays to evaluate potential acute biological effects of the observed contamination on marine invertebrates.
- Benthic community evaluations to assess potential chronic biological effects

The RI surface (0 to 10 cm) sediment sampling was conducted during three phases from April 1996 to July 1997. Each successive phase was required to fully delineate the outermost boundaries of Marine Sediments Unit surface sediment contamination. In addition to submitting samples for laboratory chemical and physical analyses, field immunoassays and visual observations were conducted at selected locations to assist in the delineation of contaminant extent. In total, 109 of 161 stations sampled are represented by laboratory data, which were subsequently compared with the sediment effects-based (or background) screening values. Figure 5 depicts the surface sediment sampling locations and Table 1 summarizes the sample analyses.

Subsurface sediment sampling was conducted during the second phase of the RI sampling activities, from September through November 1996. Shallow subsurface (0 to 20 feet below mudline) sediment cores were collected from 17 stations and generally composited in 4-foot intervals. Of the 77 resulting core samples (including duplicates), 65 were submitted for physical and chemical analyses, including PAHs. Select shallow core intervals were also composited and submitted for modified elutriate testing (MET) and dredge elutriate testing (DRET), to initially determine remedial design options. The deep subsurface (0 to 96 feet below mudline) sediment cores were collected from three locations and were continuously sampled for stratigraphic interpretations at 2-foot intervals. Select intervals were also subjected to field analyses, which including long-wave UV screening and immunoassays, or were submitted for laboratory physical testing (e.g., engineering parameters). Figure 6 depicts the subsurface

sediment sampling locations and tables 2 and 3 summarize the shallow and deep-core sample analyses, respectively.

The biological sampling conducted in support of the human health and ecological risk assessments occurred during the second phase of the RI. Surface sediment from nine Marine Sediments Unit and two Elliott Bay background stations were collected for laboratory acute bioassays (using amphipods and sand dollar larvae), benthic community enumeration and identification, a laboratory bioaccumulation test (using the clam *Macoma nasuta*), and chemical and physical analyses (see Figures 5 and 7). In addition, fish (English sole) tissues were sampled from two transects offshore of the MSU and two background transects in Elliott Bay (see Figure 8). The clam tissues were analyzed for bioaccumulative Chemicals of Concern (COCs), including PAHs and dioxins and furans. The fish tissues were also analyzed for these contaminants, with the exception of PAHs, which are readily metabolized by these receptors and were thus not likely to be detected. Table 4 provides a summary of the clam and fish tissue sample analyses.

5.3.4 Marine Sediments Unit Nature and Extent of Contamination

Sediment Contamination

Sediment problem areas and chemicals were determined based on exceedances of available effects-based screening values, or, where not available, Elliott Bay background concentrations established as part of the RI sampling program. Specifically, sediment chemical data were compared with effects-based Washington State Sediment Management Standards (SMS; WAC 173-204) or Puget Sound Apparent Effects Threshold (AET) values (see Table 5).

The Washington State Sediment Management Standards provides two sets of effects-based chemical criteria for Puget Sound sediment. Sediment Quality Standards (SQS), established as long-term cleanup goals, correspond to a sediment quality below which no adverse effects on biological resources will result. Cleanup Screening Levels (CSL) are less stringent standards that correspond to minor adverse effects thresholds for biological resources; they are typically used to determine if remediation is required in a specific area. Sediment chemical data were compared to both of these criteria.

For comparisons to the SMS, all nonionic/nonpolar organic chemicals were normalized to percent total organic carbon (TOC) content. However, if station-specific TOC content was outside of the range considered appropriate for normalization, (i.e., less than 0.5 or greater than 4.0 percent), then the nonionic/nonpolar organics chemical results were compared with Puget Sound AETs. The AETs represent the chemical concentrations above which deleterious biological effects have been demonstrated to always occur. The lowest AET (LAET) was used as the equivalent of the SQS, and the second-lowest AET (2LAET) was used in place of the CSL where TOC exceeded Ecology guidelines.

Because no sediment criteria for the protection of human health have been promulgated to date, delineation of those areas of concern for human health was based on the SMS chemical criteria. Within those areas defined by the SQS or CSL, standard risk assessment techniques

were used to evaluate threats to people eating seafood caught from the site (see Section 7, Summary of Site Risks).

In addition, regulatory sediment effects-based screening values were not available for dioxins and furans. The extent of contamination by these compounds was therefore evaluated by comparison to Elliott Bay background concentrations that were established as part of the RI sampling program (see Table 6).

Chemicals found to exceed effects-based or background screening values in surface and subsurface sediment included low molecular weight PAHs (LPAHs), high molecular weight PAHs (HPAHs), phenolic compounds, dibenzofuran, dioxins and furans, PCBs, and mercury. Tables 7 and 8 summarize the frequency of detection, minimum and maximum values and number of exceedances of criteria for surface and subsurface samples. Of the chemicals exceeding screening values, PAHs were identified as of primary concern based on their widespread distribution and magnitude of exceedance. Of the more than 100 samples analyzed, concentrations of total LPAHs exceeded SQS or LAET screening values in nearly 60 percent of the surface samples and approximately half of the subsurface samples. The CSL or 2LAET screening criteria for total LPAHs were also exceeded in nearly one-third of the surface samples and nearly 40 percent of the subsurface samples. Two individual LPAHs, acenaphthene and fluorene, exceeded their respective criteria even more frequently in both surface and subsurface samples. Concentrations of individual HPAHs and total HPAHs were typically lower than LPAHs, relative to their respective screening criteria (i.e., fewer HPAH screening criteria exceedances were observed, compared to the LPAHs). In general, concentrations of PAHs tended to decrease with distance offshore of the Upland Unit.

The depth of contamination is not homogeneous in the Marine Sediments Unit. PAHs tended to have a subsurface maxima within the top 4 feet of sediment, although concentrations in excess of screening criteria were found up to 20 ft below mudline. A study of substrate characteristics conducted by the U.S. Geological Survey (USGS) mapped areas of significant accumulation of non-native sediment or fill materials using side-scan sonar techniques. These fill areas correlated well with occurrences of subsurface contamination measured during the RI. According to the USGS, these fill materials range from about 20 feet thick near the shoreline to about 3 feet thick at the furthest boundary of the fill footprint (approximately 700 feet north of the main pier). However, the depth of contamination is not well correlated with distance from shore, possibly reflecting separate release events from the facility.

Other contaminants of concern, including phenolic compounds, dibenzofuran, and dioxins and furans, tended to occur with PAHs and were similarly present at highest concentrations at nearshore locations. Elevated concentrations of mercury and PCBs (relative to SMS screening criteria) appeared to be more localized and not related to sources from the Upland Unit, as they occurred primarily east (mercury) and west (PCBs) of the Upland Unit.

Because PAHs represent the primary contaminant of concern in the surface sediment, the results of the comparisons of these surface sediment data with SMS and AET screening values were used to define the areal extent of contamination in the Marine Sediments Unit (see Figure 9). Overall, approximately 100 acres and 1,000,000 cubic yards of sediment are

contaminated with PAHs at concentrations in excess of the lower (SQS/LAET) sediment screening values. When compared with the upper sediment screening value (CSL/2LAET), this area is reduced to approximately 50 acres and 500,000 cubic yards of contaminated material.

The results of the laboratory toxicity tests and the benthic community evaluations are discussed in Section 7 of this ROD under Ecological Risk Assessment, while the fish and clam tissue results are discussed in Section 7 under Human Health Risk Assessment.

6. CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

6.1 Land Use

The current and future land use associated with the upland portion of the site is use as part of the Port of Seattle's intermodal terminal. As such, the site will primarily be used as an industrial property. The Port has leased the property to a container transport company (a 30-year lease), and it is anticipated this property will continue to be used for container storage and transfer into the foreseeable future. The property located to the south and east of the site is also part of the intermodal yard. The property to the west of the PSR site is utilized as a barge transport facility for bulk materials, and the site is bordered to the north by Elliott Bay. A small portion of the upland area of the site immediately adjacent to the shoreline has been developed for public use, which includes an observation tower and a scenic public walkway. Access to the shoreline itself has been prohibited and is physically inaccessible from the Upland Unit through the use of fencing.

6.2 Groundwater Use

The groundwater associated with this site is not currently being utilized, nor should it be utilized for any purpose in the future. The State Department of Ecology has made a determination that groundwater beneath the PSR site is not suitable as a potable water supply, and no wells will be permitted. EPA's groundwater classification evaluation concurs with this determination. Further, EPA has determined that the groundwater associated with PSR meets the criteria necessary to set alternate concentration limits for the site-related contaminants of concern.

6.3 Surface Water Use

The PSR site is located in the southwestern portion of Elliott Bay, a deep, cold-water embayment located in east-central Puget Sound. Elliott Bay has been extensively developed for urban, port, and industrial land uses. While the intertidal/shoreline area is not accessible from the PSR site, there are a couple of beach areas exposed during low tides, and include mud- and sand-flats, as well as pilings and riprap. The Marine Sediments Unit is located in a transition zone between the estuarine environment of the Duwamish River and marine environment of Elliott Bay; the substrates and waters adjacent to the site contain habitat characteristics common to both environments. Currently, the usual and accustomed fishing grounds of the Suquamish and Muckleshoot Tribes include the site and adjacent areas, and impacts to potential tribal shellfish collection from the beach areas must be minimized to the greatest extent practicable.

7. SUMMARY OF SITE RISKS

Human health and ecological risk assessments were conducted for both the Upland Unit and the Marine Sediments Unit to evaluate the potential for current and future impacts of site-related contaminants on receptors inhabiting or visiting the PSR site. *The references cited in the following section are listed at the end of the Section.*

7.1 Upland Unit Human Health Risks

In 1990, Environmental Toxicology International (ETI) evaluated the potential risks to the health of aquatic and human receptors. Only those chemicals associated with wood preservatives and representing the greatest risk were evaluated and included selected PAH and metals, PCP and dioxins and furans. This risk assessment was designed to support interim response actions and determine the need for further investigations. Only limited data were available for the evaluation of Upland Unit site risks.

Several human health risk scenarios were examined based on future land use options. Risks of an industrial worker getting cancer from ingestion of soil and inhalation of vapors ranged as high as 1 in a 100 (1E-02), primarily from high molecular weight PAHs, arsenic, dioxins and furans. Cancer risks under a residential scenario were higher (1 in 10 to 1 in a 100; 1E-01 to 1E-02), using only a soil ingestion pathway. Risks of contracting cancer for a recreational user of the site were one to two orders of magnitude lower (1 in a hundred to 1 in 10,000; 1E-02 to 1E-04). All of these risks are greater than the acceptable risk ranges established by the NCP and the Washington State Model Toxics Control Act (MTCA) and establish the need for further action.

Early actions performed in the Upland Unit eliminated the risks associated with site exposure associated with current and expected future land use. Specifically, capping the upland area eliminated any risk associated with direct contact with contaminated soil, and because groundwater in the immediate vicinity of the Upland Unit is saline and not considered potable, no risks to upland receptors based on exposure to contaminated groundwater exist. Groundwater monitoring data and modeling results indicate that groundwater is currently meeting regulatory requirements at the point of discharge to Elliott Bay. The excess lifetime risk associated with the upland portion of the site (i.e., soil and groundwater) has been addressed. Furthermore, the current and long-term use of the upland property as an intermodal rail yard and container storage eliminates any future risks to human health or the environment associated with the Upland Unit. Given that the only remaining risks at the PSR site are associated with the Marine Sediments Unit, only those risks are described in detail in this ROD.

7.2 Marine Sediments Unit Human Health Risks

The human health risk assessment evaluated potential cancer and non-cancer risks to subsistence fishers, as represented by tribal fishers, who may consume above-average amounts of fish and shellfish from the site. Two types of risk were assessed: residual risks, or the risks remaining after a given area of the contaminated sediment is remediated; and baseline risks, or

those risks that currently exist at the Marine Sediments Unit. The former type of risk was calculated to determine reductions in risk for several cleanup scenarios.

7.2.1 Identification of Chemicals of Concern

Contaminants evaluated in the human health risk assessment included those chemicals that exceeded SMS criteria, were known to bioaccumulate, were widespread throughout the site, exceeded risk-based screening values or exceeded Elliott Bay background concentrations, if screening values were not available. Overall, individual PAHs, PCBs, and dioxins and furans were retained for the risk assessment. Mercury was initially evaluated, but was not detected in fish or shellfish tissue, and was eliminated from further study.

7.2.2 Exposure Assessment

The objective of the exposure assessment was to identify potential exposure scenarios by which contaminants of concern in site media could contact humans and to quantify the intensity and extent of that exposure. The conceptual site model depicting potential receptors and exposure pathways were presented in Section 5 (see Figure 3).

The exposure assessment focused on exposure of tribal fishers to site contaminants through consumption of fish and shellfish from the Marine Sediments Unit. Fish were chosen as a medium of concern because they were found to contain contaminants that were also detected in sediment collected from the Marine Sediments Unit which were associated with historical site activities. English sole were used as surrogate species to represent bottom fish because of their abundance at the site, extensive contact with sediment, and limited home range. Shellfish were also evaluated because edible shellfish (primarily crab and shrimp) are found in the Marine Sediments Unit. Clams were used as a surrogate species for all shellfish because of their close association with sediment and potential for human consumption. However, most shellfish consumption related to the Marine Sediments Unit is expected to come from shrimp and crab because of the limited intertidal habitat available for clamming and restricted access to the shoreline. Tables 9 and 10 identify the fish and shellfish exposure point concentrations for the chemicals of concern.

Both an average tribal fisher scenario and a reasonably maximally exposed (RME) tribal fisher scenario were evaluated to show the range of potential risks at the site. Consumption rates for fish and shellfish, as presented in a seafood consumption survey of the Tulalip and Squaxin Island Tribes of Puget Sound (Toy et al. 1996), were used as the data representing Native American fish and shellfish consumption patterns specific to the Puget Sound area. Data from this study, as well as Liao and Polissar (1996), which provided a more detailed analysis of the Toy et al. (1996) shellfish consumption data, were also used to modify the portions of consumed fish and shellfish that were considered likely to come from the MSU. Exposure point concentrations for consumers of fish and shellfish under current conditions and various cleanup scenarios were determined using a linear sediment to biota transfer model because fish tissue data were limited.

7.2.3 Toxicity Assessment

The human health toxicity assessment quantified the relationship between estimated exposure (dose) to a contaminants of concern and the increased likelihood of adverse effects. Risks of contracting cancer due to site exposure are evaluated based on toxicity factors (cancer slope factors or CSFs) promulgated by EPA (see Table 11). Quantification of non-cancer injuries relies on published reference doses (RfDs) (see Table 12).

CSFs are used to estimate the probability that a person would develop cancer given exposure to site-specific contaminants. This site-specific risk is in addition to the risk of developing cancer due to other causes over a lifetime. Consequently, the risk estimates generated in risk assessments are frequently referred to as "incremental" or "excess lifetime" cancer risks.

RfDs represent a daily contaminant intake below which no adverse human health effects are expected to occur. To evaluate noncarcinogenic health effects, the human health impact of contaminants is approximated using a hazard quotient (HQ). Hazard quotients are calculated by comparing the estimates of site-specific human exposure doses with RfDs. Values greater than 1.0 are considered to represent a potential risk.

Of the site-related contaminants of concern in fish and shellfish that potentially impact human health, only dioxins and some PAHs are considered to be carcinogenic. The potential cancer risks posed by these compounds were evaluated using EPA's toxicity equivalency factor (TEF) approach.

For PAHs, this approach assigned toxicity potency factors to carcinogenic PAHs relative to the toxicity of benzo(a)pyrene [B(a)P]. A total B(a)P equivalent concentration was derived by multiplying each individual carcinogenic PAH concentration by its equivalency factor and summing the results. Carcinogenic PAHs were combined and referred to as total B(a)P equivalents. Carcinogenicity from B(a)P equivalents was evaluated using the CSF for benzo(a)pyrene identified in the Integrated Risk Information System (IRIS; EPA 1997) (see Table 11).

Dioxin and furan compounds were also evaluated using a TEF approach, by which 2,3,7,8-TCDD equivalents were derived by multiplying each individual dioxin and furan congener by its equivalency factor and summing the results. A CSF for dioxin from the Health Effects Assessment Summary Tables was used (see Table 11).

A non-cancer RfD was identified for only one non-carcinogenic PAH (pyrene; see Table 12). No RfDs were available for dioxin, benzo(a)pyrene or its equivalents, or benzo(g,h,i)perylene or phenanthrene.

7.2.4 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. This "excess lifetime cancer risk" is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

where: risk = a unitless probability (e.g., 2×10^{-5} or $2\text{E-}5$) of an individual's developing cancer

CDI = chronic daily intake averaged over 70 years (mg/kg-day)

CSF = slope factor, expressed as (mg/kg-day)⁻¹.

(See Table 13 for a summary of the input parameters used in risk calculations.)

Risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6} or $1\text{E-}6$). An excess lifetime cancer risk of $1\text{E-}6$ indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an excess lifetime cancer risk because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as 1 in 3. EPA's generally acceptable risk range for site-related exposures is $1\text{E-}4$ to $1\text{E-}6$. Washington State Model Toxics Control Act (MTCA) rule is similar, but with the acceptable lower risk range of $1\text{E-}5$.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with an RfD derived for a similar exposure period. An RfD represents the level that an individual may be exposed to a given chemical that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ less than 1 indicates that an individual's dose of a single contaminant is less than the RfD, and that toxic effects from the chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemicals of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI less than 1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI greater than 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

$$\text{Non-cancer HQ} = \text{CDI}/\text{RfD}$$

where:

CDI = Chronic daily intake

RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

7.2.5 Cancer Risks

The results of the human health risk characterization indicated that cancer risks to subsistence fishers are the primary concern under current conditions. Cancer risks represent an individual's chance of developing cancer due to ingestion of seafood from the Marine Sediments Unit, over and above those exposures associated with general activities in a lifetime. Under current conditions, total cancer risks for the RME individual (high-end tribal fisher) are 5.2 in 10,000 ($5E-4$), when both PAHs and PCBs are considered (see Table 14). Given the uncertainties associated with estimating risks, this probability is considered accurate within an order of magnitude. Thus site risks under current conditions exceed the NCP risk ranges of $1E-6$ to $1E-4$. MTCA risk ranges do not apply directly to sediment; however, MTCA risk ranges would also be exceeded under current conditions.

7.2.6 Non-Cancer Risks

Under current conditions, non-cancer hazard indices to RME individuals based on exposure to PAHs are less than 1.0, indicating that non-cancer effects for these chemicals are likely minimal for the site. Inclusion of PCBs in the non-cancer risk assessment suggests that significant impacts to human health may occur from eating contaminated seafood ($HI = 4$) (see Table 15).

7.2.7 Discussion of Residual Risk Calculations

Residual risks (i.e., risk remaining after cleanup) for human consumers of seafood were calculated to allow comparisons among the alternatives. Individual sample data collected as part of the RI were replaced with the SQS, CSL or background chemical concentrations, depending on the configuration of the remedy. It was assumed that dredging would achieve the selected standard (either the SQS or CSL), while capping would achieve the Elliott Bay background concentration. Once the sample concentrations were replaced with the post-remedial action predicted sediment concentrations for the chemicals of concern, clam and fish tissue concentrations were estimated using a biota-sediment accumulation factor for each sample location. The 90th percentile of the resulting tissue concentrations was then used as the exposure point concentration in the human health risk assessment. The calculated residual risk for each alternative is listed in the Description of Alternatives Section.

7.2.8 Uncertainties

Risks to human health may be over- or underestimated based on the appropriateness of the assumptions regarding exposure, the availability and assumptions associated with the derivation of toxicity factors, and the use of a bioaccumulation model to represent exposure point concentrations. These inherent uncertainties were accounted for by making assumptions that tended to overestimate risk. For example, when calculating residual risk for a capping scenario, it is understood that some volume of capping material will be deposited in non-target areas (i.e., areas not in exceedance of the cleanup goals). The residual risk calculations do not reflect this additional risk reduction. However, the uncertainties in any risk assessment affect the

estimations of risk such that EPA believes that the estimates are only accurate to within an order of magnitude.

7.3 Marine Sediments Unit Ecological Risks

The ecological risk assessment evaluated the health of benthic invertebrate communities and bottom fish populations. The benthic community evaluation was based on multiple effects measures, including sediment toxicity bioassays, *in situ* benthic community structure, and clam tissue bioaccumulation data. The bottom fish evaluation was based on fish tissue bioaccumulation data and the use of a simple linear model to estimate the transfer of bioaccumulative contaminants from a fish to its eggs.

7.3.1 Identification of Chemicals of Concern

Similar to the human health risk assessment approach, contaminants evaluated in the ecological risk assessment included those chemicals that exceeded SMS criteria, were known to bioaccumulate, were widespread throughout the site, and exceeded Elliott Bay background concentrations. Overall, individual PAHs, PCB, and dioxins and furans were retained for the risk assessment. Mercury was not evaluated because it was not detected in fish or shellfish tissue.

7.3.2 Exposure Assessment

Ecological Setting

The Marine Sediments Unit consists primarily of deep subtidal habitat, as nearly all intertidal wetlands and shallow subtidal aquatic habitats in the vicinity have been eliminated as a result of urban development. Intertidal habitat does exist within the Marine Sediments Unit, but is limited to two pocket beaches at the head of the West and Main Slips and as thin bands of muddy sand beach along the toe of the riprapped banks. Because the Marine Sediments Unit is located in a transition zone between the estuarine environment of the Duwamish River and the marine environment of Elliott Bay, the substrates and waters adjacent to the site contain habitat characteristics common to both environments.

Biota utilizing the habitat within the Marine Sediments Unit include a variety of marine invertebrates, estuarine and marine fishes (including salmonids), birds, and marine mammals. Some of these species have been classified by the State of Washington and federal government as species of special concern (i.e., requiring protective measures for their perpetuation due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance). Table 16 presents the ecological receptors and exposure pathways of concern for the site. In addition, Chinook salmon and Bull trout have been listed on the federal Endangered Species List.

Exposure Point Concentrations

Exposure point concentrations were derived for sediment, benthic infauna, clams, fish, and fish eggs. Contaminant-specific exposure point concentrations for surface sediment were

represented on a station-by-station basis (rather than combined for the area) because the receptors within the benthic community are expected to have limited movement and are more likely to spend their entire lives at single, defined locations within the sediment environment. Sediment exposure point concentrations were represented by the laboratory results for PAHs and dioxins and furans, with TOC normalization of PAHs (where appropriate) and conversion of dioxin and furan congener-specific data to 2,3,7,8-TCDD equivalents (see Table 17).

Benthic exposures were also evaluated on a station-by-station basis and were represented by measures (averages) of major taxonomic group (i.e., crustacean, mollusc, and polychaete) and species-level abundance and richness. The average values for these endpoints were calculated from the replicate samples collected at each station.

Contaminant exposure to clams inhabiting the Marine Sediments Unit was estimated by directly measuring the concentrations of contaminants of concern in unpurged, whole body bent-nose clam (*Macoma nasuta*) tissues exposed to site sediments in a laboratory test (see Table 18). Similarly, contaminant exposure based on bioaccumulation in English sole was estimated by directly measuring 2,3,7,8-TCDD in whole body adult tissues of fish collected from the site (see Table 19). A maternal-egg transfer approach was used to model 2,3,7,8-TCDD exposures to fish eggs. Studies from Nimi (1983) and EPA (1993) were used as the basis for assessing the maternal transfer of TCDD.

7.3.3 Ecological Effects Assessment

Several different criteria were used to evaluate potential toxicity to a range of ecological receptors at the site. Effects-based criteria (i.e., SMS and AET chemical screening values) were used to evaluate toxicity to benthic organisms exposed to contaminated sediment. These criteria represent chemical-specific threshold concentrations above which adverse ecological impacts to the benthic community would be expected. Site-specific toxicological impacts from combined chemical contamination were also evaluated by comparing growth and mortality responses of organisms exposed to sediment collected from the site to responses of organisms in clean control sediments. These toxicological tests included amphipod, echinoderm embryo, and clam bioassays and comparisons with SMS biological criteria (or criteria modeled after SMS). Site-specific toxicological impacts from combined chemical contamination were also evaluated by comparing site-collected benthic infaunal community data, including measures of abundance and diversity, to similar samples collected from Elliott Bay (background).

Chemical-specific toxicity evaluations were conducted for measured concentrations of Contaminant of concern in fish collected from the site and in clams exposed to site-collected sediment. Estimates of fish egg concentrations were made based on a simple maternal transfer model. Toxicity to fish and eggs was also evaluated using literature-based effects concentrations of chemicals in fish tissues and background concentrations of chemicals in clam tissue.

7.3.4 Risk Characterization

Results of the ecological risk assessment showed that existing sediment contamination has low to moderate impacts on benthic invertebrate communities residing in the Marine

Sediments Unit. No risks were calculated for clams because of a lack of effects data in the literature. However, clams are exposed to site-related contaminants at levels exceeding Elliott Bay background concentrations, indicating the possibility that deleterious impacts could occur to this receptor. No risks to fish or fish eggs based on exposure to bioaccumulative contaminants in sediment were identified for the existing conditions in the Marine Sediments Unit. However, risks to fish from PAH exposures were not evaluated because tissue concentrations were considered a poor representation of exposure and potential effects, due to the metabolic breakdown of PAHs in vertebrates. As part of the review of the Feasibility Study, CERCLA Natural Resource Trustees (NOAA, Interior, Ecology, and the Suquamish and Muckleshoot Tribes) provided EPA with a restoration goal for the site, based on effects to flatfish. The restoration goal is 2,000 µg/kg (measured on a dry weight basis) total PAHs in sediments and is based on a sum of the concentrations of selected PAHs. Elliott Bay background concentrations currently exceed the restoration goal, as does the site, indicating that flatfish populations may be at risk throughout Elliott Bay.

7.3.5 Uncertainties

Risks to ecological receptors may be over- or underestimated based on the appropriateness of the background benthic area selected for comparison with Marine Sediments Unit data, the accuracy of the laboratory bioassays in predicting impacts to *in situ* receptors, the assumptions regarding the site-specific bioavailability of contaminants, the accuracy of the predictions of exposure to clams and fish that were based on average tissue concentrations and chemical detection limits, the use of a model to predict chemical concentrations in fish eggs, and the assumptions associated with effects levels for fish. However, similar to the approach used for conducting the human health risk assessment, these inherent uncertainties were accounted for by making assumptions that generally overestimate risk. The exception to the general overestimation is associated with the impact of PAHs on flatfish, as there is no standard methodology to evaluate this pathway.

7.4 Basis for Response Action

Contaminated sediment in the Marine Sediments Unit represents a threat to aquatic receptors (primarily fish and higher order receptors) and people consuming seafood from the site. The response action selected in this ROD is necessary to protect the public health and welfare and the environment from hazardous substances that occur in the surface sediments of the Marine Sediments Unit.

Wood-processing and related industrial chemicals released from the PSR Upland Unit or discharged from the Longfellow Creek overflow channel have been retained in the sediments composing the PSR Marine Sediments Unit. The chance of a tribal fisher developing cancer or other non-carcinogenic effects related to consumption of site-contaminated seafood exceeds the acceptable risk range identified in the NCP.

Aquatic invertebrates may be harmed by ingestion or exposure to contaminated sediments, depending on the sensitivity to PAHs exhibited by a species (i.e., not all species may be affected). However, recent work by the National Marine Fisheries Service (Horness et al.

1998) suggests that flatfish (or other fish in direct contact with sediments) may be at risk for impaired growth or reproduction or suppressed immune responses, not only at the site but throughout Elliott Bay.

References for Section 7

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8. REMEDIATION OBJECTIVES

8.1 Upland Unit

The remedial action objectives for the groundwater pathway are: 1) Protection of aquatic life in surface water and sediments from exposure to contaminants of concern above protective levels, and 2) protection of humans from exposure to groundwater containing contaminants of concern above protective levels. These objectives are currently being met through the implementation of the early actions. Additional remedial measures will ensure that the early actions remain protective.

8.2 Marine Sediments Unit

The remedial action objectives for sediments associated with this site are: 1) to minimize human exposure through seafood consumption and 2) minimize benthic community exposure to site contaminants. These objectives will be met through remediation of the sediments exceeding the following State standards: 1) the minimum cleanup standard (CSL) under the State Sediment Management Standards for sediments contaminated with PAHs (creosote related contamination),

and 2) the State's sediment quality standard (SQS) for sediments contaminated with PCBs in the near shore environment. PCB cleanup can be easily addressed during PAH cleanup and may increase the overall health of Elliott Bay. A more stringent cleanup goal was chosen for PCBs due to their potential for bioaccumulation in the food chain. These cleanup levels will result in approximately 50 acres of contaminated sediments being actively remediated. Human exposure to contaminated seafood and benthic exposure to contaminated sediment associated with this site will be nearly eliminated in the capped areas, as the fish, shellfish, and benthic community will no longer be exposed to the contaminated sediment. Rather they will be exposed to the clean sediment imported for capping material.

8.3 Key Applicable or Relevant and Appropriate Requirements

The key Applicable or Relevant and Appropriate Requirements (ARARs) for PSR include the Alternative Cleanup Levels (ACLs) and the State Model Toxics Control Act (MTCA) for groundwater, and the Washington Sediment Management standards for the marine sediments, as described below.

8.3.1 Upland Unit

Alternate Concentration Limits for Groundwater

Usable groundwater should be returned to beneficial uses wherever practicable within a reasonable restoration time frame (40 CFR 300.430(a)(iii)(F)). If groundwater is a current or potential future source of drinking water, remedial actions must reduce contaminant concentrations to or below nonzero maximum contaminant level goals (MCLGs) or maximum contaminant levels (MCLs) established under Safe Drinking Water Act regulations (40 CFR 300.430(e)(i)(B)). However, under the following circumstances, alternate concentration limits (ACLs) in accordance with CERCLA Section 121(d)(2)(B)(ii) may be used (40 CFR 300.430(e)(i)(F)):

- The groundwater must have a known or projected point of entry to surface water
- Measurements or projections must show that there is or will be no statistically significant increase of such constituents in the surface water at the point of entry or at any point where accumulation of constituents may occur downstream
- The remedial action must include enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of groundwater entry into surface water

MTCA (WAC 173-340-720(1)(c)) lists parallel requirements, and the PSR site meets the criteria as follows:

- Groundwater from the PSR site discharges directly into Elliott Bay at known or projected points (see Figure 10).
- Uplands RI/FS calculations of constituent concentrations from shoreline monitoring well data project that there will be no statistically significant increase in contaminants in Elliott Bay, after groundwater contaminant concentrations are attenuated between the shoreline

wells and the marine water/sediment interface (i.e., the mudline). Under the MTCA, the shoreline wells would be considered an alternate point of compliance, as they will be used to predict the contaminant concentration at the mudline.

- Enforceable institutional controls outlined in this ROD will preclude human exposure to on-site groundwater and any groundwater between the site and Elliott Bay.

Both Class II and Class III groundwater exist at PSR (see Figure 10). Class III groundwater occurs where saltwater intrusion (i.e., the saltwater wedge) raises total dissolved solids concentrations above 10,000 mg/L. Class II groundwater occurs above and upgradient of the 10,000 mg/L boundary. The assignment of Class II to this groundwater is consistent with EPA's definition of a potential source of drinking water (i.e., one available in sufficient quantity to meet the needs of an average household.)

Restoration of Class II groundwater at PSR is impracticable. DNAPL at PSR represents a long-term continuing source of contamination to groundwater. The DNAPL is widespread and the distribution is complex as a result of the interbedding of coarse and fine-grained soil layers in the aquifer (Sections 4.2.2, 4.2.3 and 9.1.4 of the Upland RI/FS). Currently available remedial technologies cannot restore the aquifer to drinking water standards.

Based on the groundwater classification at PSR, the impracticability of restoration, and the impracticability of the site meeting the statutory requirements, use of ACLs at PSR is appropriate. The ACLs for the PSR site are the maximum allowable source concentrations. A fate and transport analysis was conducted using the Domenico Solution to determine allowable source concentrations at shoreline monitoring wells that ensure protection of receptors at the mudline. The mechanisms modeled between the shoreline wells and the mudline were dispersion, sorption, diffusion and tidal dilution. The contribution of biodegradation was not included due to a lack of site-specific degradation data.

Alternate concentration limits were calculated for each of the shoreline well-sets that span shallow (9 to -6 feet MLLW), intermediate (-20 to -40 feet MLLW) and deep (-75 to -85 feet MLLW) screen intervals. For each set, the maximum allowable source concentrations are based on the minimum estimated travel distance between the well-screen and the mudline. As shown in Table 20, many of the calculated ACLs exceeded individual compound solubilities which are the maximum dissolved concentrations possible at equilibrium (i.e., compound is not predicted to dissolve at a high enough rate to exceed the ACL). Compliance with ACLs will be confirmed by groundwater monitoring in shoreline wells.

8.3.2 Marine Sediments Unit

Washington Sediment Management Standards (WAC 173-204)

The Washington Sediment Management Standards (SMS) have been identified as one key ARAR for all Marine Sediments Unit actions. The SMS establish a narrative standard with specific biological effects criteria and numerical chemical concentrations for Puget Sound sediment. Under the SMS, the cleanup of a site should result in the elimination of adverse effects on biological resources and health threats to humans. The Sediment Quality Standards

(SQS) correspond to this narrative goal for ecological effects. Site-specific cleanup standards are established from a range of concentrations; they are to be as close as practicable to the SQS and no greater than the minimum cleanup levels (MCUL; equivalent to the CSL), based on environmental effects, feasibility, and cost.

Given site-specific factors, the CSL for PAHs has been selected as the trigger for active remediation of sediments throughout the PSR Marine Sediments Unit and the SQS for PCBs has been selected as the trigger for active remediation of sediments in the nearshore environment (i.e., sediments shallower than -10 feet MLLW). Table 20 summarizes these values.

The justification for the selection of the CSL for PAHs is as follows:

- The CSL is protective of benthic communities (as determined by biological sampling).
- Human health risks fall within the risk range required by the NCP.
- Cleanup costs to achieve the SQS across the entire site were greater than 190 percent of the cost to achieve CSLs (greater than 110 percent is considered significant under the SMS guidance).
- Cleanup to the CSL addresses the areas of contaminated sediment accumulations, which contain the greatest mass of contaminants.
- The majority of the unremediated sediments that will remain following cleanup are in deep (greater than 100 feet) water, providing minimal exposure potential to fishers and recreational users of the bay.

The justification for the selection of the SQS for PCBs in the nearshore environment is as follows:

- The nearshore environment provides critical habitat for juvenile salmonids and their prey.
- The CSL for PCBs does not provide the same degree of protection as other chemicals because it does not address bioaccumulative effects.
- Cleanup of PCBs to SQS ensures that the Trustees' restoration goal for PAHs is met in the shallow, nearshore critical habitat area (some nearshore areas where PCBs exceed the SQS also include PAH contamination that exceeds the SQS).

9. DESCRIPTION OF ALTERNATIVES

The Upland Unit and Marine Sediments Unit remedial alternative descriptions are presented separately. The completed and on-going Upland Unit actions and the selected Marine Sediments Unit alternative, in combination, constitute the PSR site-wide remedy.

9.1 Upland Unit

9.1.1 Completed Early Actions

Early cleanup actions were completed to address threats posed by contaminated soil and groundwater and shallow NAPL in the Upland Unit. Included in these actions were the installation of a subsurface containment wall and LNAPL collection trench along the northern site perimeter and the placement of a low-permeability surface cap over the Upland Unit. The subsurface slurry wall was designed to minimize flow of contaminated groundwater and LNAPL to Elliott Bay and reduce tidal influence on contaminant movement below ground surface. The selection of this particular containment option is discussed below. The purpose of the cap was to isolate contaminated soil and reduce groundwater recharge (and associated contaminant mobilization). Early actions were completed prior to the RI/FS process.

Two general response actions were considered for subsurface containment: hydraulic containment and physical containment. Physical containment was selected primarily because LNAPL seeps to Elliott Bay could be prevented. Three types of physical containment technologies were evaluated: sheetpiles, slurry walls, and grout curtains. Grout curtains were eliminated based on technical feasibility concerns; the integrity of curtains in heterogeneous fill conditions and high groundwater tables is uncertain. Slurry wall technology was selected rather than sheet pile technology due to its lower cost. The final remedial action selected was the implementation of an upland hanging slurry wall.

PSR groundwater meets cleanup requirements under the NCP and threshold requirements for cleanup actions under MTCA without implementation of additional engineered remedial measures. What was selected as an early action is the final action, and the development and detailed evaluation of a series of cleanup alternatives was not required for the Upland Unit.

9.1.2 Requirements to Ensure Upland Unit Actions Remain Protective

Engineering Controls

A Inspection and Maintenance (I&M) program was developed to ensure the long-term structural integrity of the cap installed over the Upland Unit. The program consists of scheduled visual cap inspections and specific repair and maintenance protocols. Additionally, every five years the Port will evaluate the need to resurface the upper two inches of the asphalt and determine if reapplication of the cap seal coat is warranted.

Institutional Controls

Institutional controls are the use of legal or administrative systems to reduce the potential for human exposure to contaminated soil and groundwater in the Upland Unit. As described in Section 6, the current and projected future land use of the Upland Unit is primarily industrial (i.e., use as a paved intermodal rail yard) and the groundwater beneath the PSR site will not be used as a potable water supply. The institutional controls necessary to ensure the continued protection provided by the early actions are actions that will assure the current land use is maintained and the aquifer remains unused.

Monitoring

Confirmational monitoring is a routine requirement under CERCLA, as well as one of the threshold requirements for cleanup actions under MTCA and is the central purpose of the plan. Monitoring is intended to confirm the long-term effectiveness of the early actions.

Monitoring of the Upland Unit will consist of two components. The first component is the monitoring of groundwater quality to ensure compliance levels continue to be met (i.e., concentrations of contaminants of concern do not exceed cleanup levels at the mudline). Because the direct measurement of water quality at the mudline is impracticable, monitoring wells located in the shoreline area are utilized to evaluate compliance. These wells allow for monitoring of groundwater quality at two depths outside the containment wall and along the shoreline.

The second component is designed to monitor DNAPL attenuation. This monitoring is required to confirm the conclusion in the RI that the volume of mobile, free-phase DNAPL beneath the site is very limited, and to provide a warning in the case of an unexpected change in conditions. This component consists of gauging DNAPL thickness in wells and removing DNAPL from wells.

9.2 Marine Sediments Unit

Six candidate alternatives were identified in the Marine Sediments Unit FS:

1. No Action
2. Removal (via dredging and disposal) of sediment exceeding the CSL
- 3a. Capping of sediment exceeding SQS
- 3b. Capping of sediment exceeding CSL
- 4a. Fill Area Removal (via dredging and disposal) of sediment exceeding the SQS and then capping the remaining non-Fill Area sediment exceeding SQS
- 4b. Fill Area Removal (via dredging and disposal) of sediment exceeding the CSL and then capping the remaining non-Fill Area sediment exceeding CSL.

9.2.1 Estimated Cleanup Areas and Volumes

The numeric cleanup goals to attain the Marine Sediments Unit Remedial Action Objectives (RAOs) are the SMS criteria. The PSR cleanup levels are CSLs for PAHs (throughout the Marine Sediments Unit) and SQS for PCBs (in less the -10 feet MLLW). See Table 5 for a summary of these levels. The areas with surface sediment exceeding SQS or CSL criteria for PAHs are depicted in Figure 9. The SQS exceedance area represents about 96 acres and 970,000 cubic yards of contaminated material; within that area, 47 acres or approximately 470,000 cubic yards of sediment also exceed CSLs. Nearly all sediment volume exceeding CSL

and SQS criteria (90 and 85 percent, respectively) is located at depths of less than -200 feet MLLW.

The majority of the contaminant mass exists in the Fill Area. The Fill Area sediment contains approximately 96 percent of the mass of contaminants exceeding the SQS criteria, while comprising only 39 percent of the total volume of SQS-contaminated sediment, and contains approximately 98 percent of the mass of contaminants exceeding the CSL criteria, while comprising only 70 percent of the total volume of CSL-contaminated sediment.

9.2.2 Common Components of Alternatives

With the exception of the No Action alternative, each of the sediment remedial alternatives for Marine Sediments Unit share certain components, such as institutional controls and short- and long-term monitoring. For dredging and disposal, additional common elements include methods of sediment removal and transport, and potential disposal site options. For capping, additional common components include cap material availability, methods of material transport and placement, and navigational constraints. Table 21 provides a summary of Marine Sediments Unit remedial alternatives and summarizes which common elements are associated with each alternative. Brief discussions of the common alternative components are provided below.

Another common element to the Marine Sediments Unit remedial alternatives is that they all include the requirements to ensure the Upland Unit actions remain protective (described in Section 9.1.2) to comprise the site-wide remedial alternative for PSR.

Institutional Controls

Currently, the Upland Unit shoreline is fenced to prevent access to the shoreline (by land) and fishing exclusion devices are installed along the viewing pier.

For alternatives with capping components, institutional controls to maintain cap performance will be required. These controls will include administrative measures or regulatory actions to prevent maintenance dredging and large ship anchorage in capped areas. A no-anchor zone is proposed for all alternatives in areas that would be capped. The extent of the zone would depend upon the size of the area capped for the alternative (see Table 21). For the alternatives consisting primarily of capping (Alternatives 3a and 3b), the no-anchor zone would be approximately 96 or 47 acres in size, respectively, representing about 4 or 2 percent of the total anchorage area available in Elliott Bay (approximately 2,000 acres are designated for anchorage within Elliott Bay). This institutional control is included to prevent damage to the cap from commercial vessels using large whale-type anchors. Currently, the Marine Sediments Unit is used only for barge moorage at fixed anchor buoys. This type of moorage will not be restricted. In addition, this restriction would not affect net fishers because small boat anchors and net lead-lines would not damage the cap.

Monitoring

Site monitoring will be conducted for all alternatives. Although specific monitoring requirements vary depending upon the alternative, it is assumed that three types of monitoring will be carried out. Short-term monitoring will be performed during remedial action implementation to ensure compliance with water quality requirements, confirmational monitoring will be implemented immediately following the action to ensure the actions was implemented as designed, and long-term monitoring will be performed to ensure the performance of the remedy. Specific monitoring programs will be developed for the site during remedial design.

Dredging and Transport

Two general types of dredges, clamshell (or bucket) and hydraulic, were evaluated during the FS as applicable to potential sediment removal actions. The dredging-specific methods evaluated were closed clamshell dredge, cutterhead section dredge, high-energy vortex dredge, and a limited-access hydraulic dredge, which represent the most widely used classes of dredges available. Each of these dredges has different attributes with respect to excavation capacity, depth limitations, sediment loss or expansion (bulking), and production rates of dredge material (see Table 22). Comparisons among these dredges indicated that the majority of the sediments from the Marine Sediments Unit could be removed using either a clamshell dredge or large hydraulic dredge. For the purposes of the cost estimates, it was generally assumed that a clamshell dredge would be used in nearshore areas and the high-energy vortex dredge in deeper, offshore areas.

Two methods are used to transport dredged material: pipeline and barge. The actual sediment transport method selected depends primarily on the dredging method and the distance to the disposal site. Pipeline transport was generally assumed for cost estimate purposes, based on the selected dredging method. However, final transport methods would be determined during remedial design when the final dredge equipment and disposal sites are selected.

Crowley Marine Terminal Dredging

All alternatives include dredging in the area of the Crowley Marine Services (CMS) terminal, a barge terminal at Pier 2 (just west of PSR) in order to maintain adequate depths for maneuvering and moorage of barges. Dredging is employed to remove contaminated sediments from the pier area, while maintaining current depths (to accommodate vessel depth requirements) after capping. The disposal method for dredged material varies, depending on the alternative.

Capping

Capping as a remedial technology involves placement of clean substrate (typically sand) to some specified depth over the contaminated sediments. Typical placement methods includes controlled dumping from a split-hulled barge, hydraulic washing of capping material off a flat-decked barge, distribution via a submerged diffuser, and clamshell placement. Requirements for capping material depend upon site-specific characteristics, including water depth, bathymetry,

currents, and chemical and physical characteristics of the area to be capped, and are typically determined during design. Site-specific physical constraints that affect capping include currents, wave action, propeller wash, slope, and depth.

For the purposes of evaluating the capping alternatives and estimating costs in the FS, a 3-foot layer of silty sand was assumed to chemically and physically confine the majority of the Marine Sediments Unit sediments exceeding SQS or CSL criteria. Actual cap thickness requirements are determined during design. As the accuracy of cap placement and the capability of monitoring cap thickness is reduced with increasing water depth, it was further assumed that an average cap thickness of 5 feet would be needed to ensure a minimum cap thickness of 3 feet at depths greater than -200 feet MLLW. Because of the potential for resuspension of fine-grained contaminated sediment during cap placement, it was assumed that less dynamic or disruptive methods of sediment placement would be used in the offshore area, such as hydraulic washing. Nearshore area placement techniques were assumed to rely on clamshell placement to obtain desired placement accuracy.

The source of capping material was assumed to be from maintenance dredging projects performed for navigational purposes by the U.S. Army Corps of Engineers (Corps). Table 23 presents the capping material source locations and projected availability schedules. Information provided by the Corps indicates that the two largest sources of sediment suitable for capping are the Snohomish and Duwamish rivers. Dredged material from these projects is anticipated to be predominantly sand materials. Given the demands for capping material throughout Puget Sound, coordination with the Puget Sound Dredge Materials Management Program to develop priorities and schedules for the beneficial reuse of clean dredge material will be needed.

In addition to navigational dredging projects, the dredging of clean sediments in other areas was considered as an alternative capping material source and deemed inappropriate. The mining of clean sediment could have a deleterious effect on the benthos if large areas were mined in order to get the quantity of sediment needed quickly and is difficult to get permitted. In addition, capping the sediment over several years (as necessitated by the projected availability capping material from maintenance dredging projects) will allow the benthic community to re-establish itself between capping events such that a large area is not disrupted at one time. Another benefit of capping over several years is that it allows the effectiveness of capping at depth and over steep slopes to be better established through monitoring to perfect the operation from one year to the next.

Groundwater Discharge Zone Capping

The intermediate groundwater discharge zone, located in the west-central portion of the Marine Sediments Unit, has been identified as an area susceptible to recontamination (due to predicted groundwater contaminant transport in this area). To achieve cleanup goals and long-term protectiveness, a three-foot cap would be placed in the intermediate groundwater discharge zone for all alternatives. In alternatives where dredging is performed first, capping would follow.

9.2.3 Disposal Sites

Disposal options for contaminated dredged sediment consist of confined nearshore disposal (CND), confined aquatic disposal (CAD), or upland disposal. During the FS, the CND option was identified as preferable for alternatives involving the disposal of relatively large volumes of dredged sediment (i.e., Alternative 2, 4a, and 4b).

Confined Nearshore Disposal

A CND facility is typically constructed adjacent to an upland area such that the site can be used as an extension of the upland when the site is filled with sediment. Potential nearshore disposal sites were identified based on several selection criteria. To qualify as a potential nearshore disposal site, the area had to be located in Elliott Bay. In addition, the geomorphology of the site had to be stable enough to allow the construction of a retaining berm. Location of nearshore disposal facilities could not conflict with current land or shoreline uses or tribal fishing activities. The site could not be located in high-value aquatic habitat areas or habitat restoration or enhancement areas. Ten sites were evaluated according to these criteria. Of the 10 sites evaluated, only the nearshore areas associated with PSR and the former Lockheed Shipyard #2 which is adjacent to PSR, is currently available for use as a disposal site for dredged material from PSR. In general, CND facilities can be constructed as an extension to the upland, or at intertidal and/or subtidal elevations. Although evaluated, an intertidal CND site was not selected for further consideration due to inadequate capacity.

The construction of a CND site has been proposed for the above-mentioned Lockheed facility by Ecology. The CND facility is proposed to be constructed off the north shore of the Lockheed site extending eastward from the PSR site to the West Waterway. The facility consists predominantly of an intertidal disposal area supported by a constructed subtidal area. Site capacity would be filled by the Lockheed site cleanup in the current site configuration. However, if the CND at Lockheed was reconfigured to result in a final elevation equivalent to the current upland, the facility could accommodate PSR sediments. Integration of the PSR nearshore disposal site with the Lockheed intertidal disposal site would consist of constructing the Lockheed site such that it abuts the east side of the PSR disposal site and the utilization of the east side of the PSR berm for confinement. Two nearshore disposal site configurations were retained as CND facility options with capacities of 350,000 cubic yards to 480,000 cubic yards.

The CND facility berm could consist of riprap with sand infill to act as a barrier to sediment migration through any gaps in the riprap. Dredge water from inside the disposal area could be released through a notch in the top of the berm. Modified elutriate tests (METs) were performed to predict the effluent quality from nearshore dewatering operations. The test results indicate that the discharge of separable dredge water could result in exceedances of federal marine acute ambient water quality criteria (AWQC) for two LPAHs (phenanthrene and naphthalene). To protect water quality during the dewatering of dredged sediment, the separable dredge water would be detained using an oil boom and/or activated carbon filter and treated prior to discharge. Water quality sampling would be performed to ensure contaminant levels were acceptable.

To maintain slope stability, dredging of contaminated sediments would not be conducted adjacent to the riprap containment berm. Capping of the sediments adjacent to the CND would be the preferred option.

For cost estimation purposes, it was assumed that vortex hydraulic dredging would be used to minimize solids resuspension, and the hydraulically dredged solids would be pumped via floating pipeline. The area within the berm would be filled with contaminated sediment to an elevation of approximately 10 feet MLLW to ensure that the sediments remain saturated. The remaining three to five feet would be filled with clean material to serve as a cap.

To incorporate habitat into the PSR nearshore disposal facility design, the outer perimeter of the berm should be covered with fine substrate conducive to benthic habitat. This would create a 5-acre intertidal area extending outward from the top of the berm to a distance of approximately 150 feet at a 3:1 slope. It would range in elevation from -35 feet MLLW to 15 feet MLLW.

Confined Aquatic Disposal

A CAD facility would consist of consolidating the contaminated dredged sediment on a minimally sloping section of Elliott Bay and covering it with clean sand. Potential CAD sites were identified based on several criteria, including proximity to PSR, physical dimensions of the site, neighboring activities, and ecological importance of the site. Specifically, only sites located in Elliott Bay were considered. In addition, sites had to be located at depths between -80 and -200 feet MLLW and have a slope of 6 percent or less. The final consideration was that the site could not be located in high-value aquatic habitat areas or designated mitigation areas. Based on these criteria, two potential CAD sites were identified.

CAD Site 1 is located approximately 0.5 miles northeast of the PSR upland site and lies adjacent the PSDDA disposal site boundary. CAD Site 2 is located in the northwest portion of Elliott Bay near Terminal 91 and the Elliott Bay Marina. This site is approximately 3 miles north-northeast of the PSR upland site.

To minimize water quality impacts at the CAD disposal site, contaminated sediments should have high density for faster settling and less spreading upon placement into the CAD. Therefore, to implement the CAD disposal option, it would be necessary to dredge Marine Sediments Unit sediments with a closed clamshell dredge to maintain greater than 60 percent of the *in situ* sediment density. (Note: descriptions and evaluations of alternatives assume the use of a vortex hydraulic dredge).

The native sediments in the area of the CAD sites would be dredged to form a depression in which to place the contaminated sediment. This depression, in conjunction with capping, would confine the contaminated sediment. The clean dredged material could be temporarily placed adjacent to the selected CAD site for capping material. Alternately, a berm could be constructed and the dredged sediment placed within this bermed area. The estimated capacity of each site assumes the site is dredged 15 feet deep with side slopes of 10H:1V.

The volume of clean material required to cap the CAD site was determined using a target thickness of 6 feet (5 feet plus 20 percent material loss) to ensure a 3-foot minimum thickness was achieved over the dredged material. The capping material should be composed primarily of sand to minimize material losses of finer-grained materials.

Upland Disposal

Upland disposal consist of dewatering sediment and disposing of the dewatered sediment in an existing landfill or a newly constructed upland facility. Based on the maximum concentration of contaminants reported in the RI, it is assumed that the sediments would not be considered a Dangerous Waste as defined in Washington State Regulation, and could be disposed of as a solid waste. In addition, pursuant to RCRA (40 CFR Part 261.4(g)), because this dredged material will be subject to the requirements of Section 404 of the Clean Water Act, this material is not a RCRA hazardous waste.

Twelve areas were recommended by the Corps as potential sites for the construction of new upland disposal facility. These sites were evaluated based on current land use and site characteristics. Ten sites were eliminated from further consideration based on current land use (i.e., golf course, park, or watershed buffer zone). Of the two remaining sites, the first is owned by the City of Kent and consists of approximately 152 acres zoned for industrial use. This undeveloped property is located south of South 212th Street and east of the Green River. The eastern portion of the site (approximately 30 acres) is located within the 100-year floodplain. The site is flat and the depth to groundwater is approximately 10 to 15 feet bgs. This site is located approximately 18 miles (via Interstate 5) from PSR. The second site is owned by the City of Renton and consists of approximately 73 acres zoned for industrial use. This undeveloped property is located south of Southwest 27th Street, and east and west of Long Acres Parkway, within 0.5 mile (east) of the Green River. The site is flat and the depth to groundwater is approximately 10 to 15 feet bgs. This site is located approximately 16 miles from PSR via Interstate 5 and SR-405.

For the remedial alternatives it is assumed that vortex hydraulic dredging would be used to remove the contaminated sediments from the Marine Sediments Unit. The hydraulically dredged sediments would be transported to a dewatering system consisting of two 2-to 3-acre dewatering cells (site is currently undetermined, but would need to be in close proximity). After dewatering, the sediments would be transported to the upland disposal site via trucks (rail access is not available for either of the two potential disposal sites).

Construction of a lined landfill would be needed to contain the dredged sediments. Washington State Code requires at least 10 feet between the bottom of a landfill and the seasonal high water elevation; therefore, the landfill would need to be constructed above the ground surface. Assuming the dredged material was placed with a 10-foot average fill thickness, a minimum of 35 acres would be needed to contain 480,000 cubic yards (Alternatives 2 and 4a), and a minimum of 25 acres would be needed to contain the 315,000 cubic yards (Alternative 4b) of dredged material. Due to shallow groundwater at the potential disposal sites, sufficient capping material may not be available from landfill construction. Capping material would need to be imported or obtained from other portions of these sites not used for the landfill.

Alternatively, an established landfill could be used. Sediment dewatering could be performed using dewatering cells near the point of dredging (as suggested above). The sediment may also require stabilization to ensure no free water was present prior to transport, potentially necessitating the addition of 10 to 50 percent stabilizing agent by volume. Alternatively, sediment could be pumped to intermodal containers (if rail cars are to be used for transport) and dewatered in place using a vacuum system. The dewatered sediment could be loaded into trucks or transported by rail to an appropriate existing landfill.

9.2.4 Description of the Alternatives

Each candidate alternative represents a combination of the major elements described above. This section presents summarized alternative descriptions. Detailed descriptions are presented in the Marine Sediments Unit FS; however, several modifications have been made to the alternatives since the FS report. These changes include: 1) capping the nearshore areas with 5 feet of material, rather than 3 feet of material, to preserve tribal fishing rights, 2) disposing of sediment dredged at the CMS Terminal in an existing upland disposal facility, rather than placing it off-shore under a cap, and 3) implementing mitigation actions with nearshore sediment disposal. Therefore, alternative costs and capping material volumes presented herein differ slightly from those provided in the FS.

Alternative 1 – No Action

The No Action alternative represents a baseline against which the effectiveness of other sediment remedial alternatives can be compared. Under the No Action alternative, no removal or isolation of the contaminated sediment would occur, and no engineering or administrative controls would be implemented to prevent exposure of contaminants to human or ecological receptors. Potential impacts of the No Action alternative include the following:

- Continued potential for human health effects associated with consumption of contaminated fish and shellfish
- Continued bioaccumulation of chemicals of concern in the aquatic food chain
- Continued low- to moderate-level impacts to the benthic communities (reducing the value of contaminated areas as habitat for fishery resources)
- Continued loss of contaminants to the water column (i.e., via dissolution)
- Continued acute and chronic toxicity to marine organisms associated with Marine Sediments Unit sediment
- Potential off-site transport of contaminated sediments to other areas within Elliott Bay

Under the No Action alternative, the human health risks associated with site-related contaminants would remain at their current level of approximately 5 in 10,000 with a non-cancer Hazard Index of 4.

Alternative 2 – Removal to the CSL

Alternative 2 consists of dredging the majority of sediments from the Marine Sediments Unit that exceed CSL criteria, disposing of the dredged sediment in a nearshore disposal site, and capping isolated areas for which dredging is not a feasible alternative due to concerns regarding slope stability, recontamination, or dredging impracticability. Dredging and disposal of all sediment that exceeds SQS criteria was not considered for detailed evaluation under this alternative for several reasons. First, it would be technically very difficult, as removal would be required beyond the practical depth limitations for dredging of 200 feet. Second, no local disposal sites were identified that could accommodate 970,000 cubic yards of dredge material, thereby limiting sediment disposal options. Finally, it was determined that other, less-expensive technologies (e.g., capping) could provide the same level of protectiveness at a cost substantially less than the \$60 million estimated for nearshore disposal of sediment dredged to the SQS.

Dredging of sediment exceeding CSL criteria would be conducted from the nearshore area to a maximum depth of -200 feet MLLW (the assumed practical limits for dredging). Approximately 33 acres of the Marine Sediments Unit would be dredged to depths ranging from approximately 4 to 16 feet below mudline, resulting in the removal of approximately 372,000 cubic yards of sediment. Dredged sediments would be transported directly to a CND site. Assuming a 15 percent bulking factor, the disposal facility would require a storage capacity of approximately 428,000 cubic yards. If a CND site is not feasible, the dredged sediment would be disposed in a CAD facility or dewatered and placed in a newly constructed upland disposal facility.

Under this alternative, capping would also be conducted in three areas: along the shoreline, within the intermediate groundwater discharge zone west of the Main Slip, and in offshore areas with CSL exceedances that are at depths greater than -200 feet MLLW. Sediment in these areas would be isolated by 3-foot caps (excluding intertidal areas which are covered with a 5-foot cap) requiring a total volume of approximately 115,000 cubic yards of clean sediment and covering a total estimated area of 14.3 acres. This alternative requires an implementation period of approximately 2.7 years, depending upon the availability of capping material.

Under this alternative, the residual human health risks associated with site-related contaminants left in place would be approximately 1 in 10,000. The resulting non-cancer Hazard Index associated with the site would be less than 1.0.

The total cost of this alternative is approximately \$22,388,000 using the nearshore disposal option, \$13,714,000 using the CAD disposal option, and \$25,270,000 using a newly constructed upland disposal facility option. The following cost table summarizes the dredging costs (see Table 26 for cost estimation assumptions):

Capitol Cost	Annual O&M	Total Present Worth
\$4,806,000	\$79,860	\$6,010,000

The estimated cost of Alternative 2 is as follows:

Total Present Worth:	6,010,000
+ CND Disposal:	11,128,000
+ Mitigation:	5,250,000
= Total Cost:	\$22,388,000

Alternative 3a – Capping to SQS

Alternative 3a consists of capping all sediments that exceed the SQS except where capping would interfere with navigation at the CMS terminal. In this area, limited dredging would be performed prior to capping. Approximately 3,500 cubic yards of sediment would be dredged from this area (to a depth of approximately 3 feet below mudline), dewatered and placed in an existing upland disposal facility.

Placement of a 3-foot cap over all sediments contaminated with PAHs at concentrations greater than SQS criteria and placement of 5 feet of material in the intertidal areas would require a total of approximately 786,000 cubic yards of sediment, isolating an estimated 96 acres of offshore, shoreline, and groundwater discharge zone contaminated sediments. Based on the limited annual availability of capping material, the cap would be constructed in stages over a five-year span.

Residual human health risks associated with site-related contaminants would be approximately 3 in 100,000. The resulting non-cancer Hazard Index associated with the site would be less than 1.

The total cost of this alternative is approximately \$13,139,000, including the costs for the disposal of dredged sediment in an existing upland facility. The following table summarizes the capping costs (see Table 27 for cost estimation assumptions):

Capitol Cost	Annual O&M	Total Present Worth
\$9,613,000	\$191,400	\$12,520,000

The estimated cost of Alternative 3a is as follows:

Total Present Worth:	12,520,000
+ Existing Upland Disposal:	619,000
+ Mitigation:	N/A
= Total Cost:	\$13,139,000

Alternative 3b – Capping to CSL

Alternative 3b consists of capping all sediment that exceeds the CSL-based cleanup goals for PAHs and those nearshore areas (less than -10 feet MLLW) that exceed the SQS for PCBs. In addition, the shoreline area will be capped with five feet of material. Like Alternative 3a, limited dredging would be performed prior to capping at the CMS terminal and the dredged sediment would be dewatered and placed in an existing upland disposal facility.

Placement of a 3-foot cap over all sediments contaminated with PAHs at concentrations greater than CSL criteria, and placement of 5 feet of material in the intertidal areas would require a total of approximately 371,000 cubic yards of sediment, isolating an estimated 47 acres of offshore, nearshore, and groundwater discharge zone contaminated sediments. As with Alternative 3b, capping would be conducted in stages over an approximate 4-year span based on the availability of Puget Sound maintenance dredge material.

Residual human health risks associated with site-related contaminants after capping to CSLs would be approximately 4 in 100,000. The resulting non-cancer Hazard Index associated with the site would be less than 1.

The total cost of this alternative is approximately \$7,059,000, including the costs for the disposal of dredged sediment in an existing upland facility. The following table summarizes capping costs (see Table 28 for cost estimation assumptions):

Capitol Cost	Annual O&M	Total Present Worth
\$4,930,000	\$105,285	\$6,440,000

The estimated cost of Alternative 3b is as follows:

Total Present Worth:	6,440,000
+ Existing Upland Disposal:	619,000
+ Mitigation:	N/A
= Total Cost:	\$7,059,000

Alternative 4a – Fill Area Removal to SQS and Capping

Alternative 4a consists of dredging the fill area to depths that achieve SQS criteria (thereby removing 96 percent of the mass of contaminants exceeding SQS criteria) and capping all remaining sediment (outside of the fill area) that exceeds these criteria. In addition, similar to Alternatives 2, 3a and 3b, limited dredging would be performed at the CMS terminal prior to capping.

A total of approximately 381,500 cubic yards of material would be dredged from the 24-acre Fill Area, the 4-acre groundwater discharge zone, and the 4-acre CMS Terminal area.

Sediment removed from the CMS Terminal would be placed outward of the CMS where capping would occur in conjunction with the rest of the Marine Sediments Unit. The remaining dredged sediments would require disposal in a facility with a storage capacity of approximately 439,000 cubic yards (assuming a 15 percent bulking factor). Dredged sediments would be transported directly to a CND site. If a CND site is not feasible, the dredged sediment would be disposed in a CAD facility or dewatered and placed in a newly constructed upland disposal facility. This decision would be made during remedial design.

A 3-foot cap would be placed over the remaining 70 acres of sediment exceeding SQS chemical criteria, extending from near the shoreline to a depth of approximately -240 feet MLLW. Approximately 577,000 cubic yards of capping material would be required to ensure adequate containment. An additional 8,000 cubic yards of sediment would be required to establish a 5-foot cap over the intertidal areas. As with Alternatives 3a and 3b, capping would be done in stages over an approximate 5-year span based on the availability of clean, Puget Sound maintenance dredge material.

For fill removal and capping to SQS, the residual human health risks associated with the remediated site would be approximately 7 in 100,000. The resulting non-cancer Hazard Index associated with the site would be less than 1.

The total cost of this alternative is approximately \$29,094,000 using the nearshore disposal option, \$20,332,000 using the CAD disposal option, and \$32,185,000 using a newly constructed upland disposal facility option. The following cost table summarizes the dredging and capping costs (see Table 30 for cost estimation assumptions):

Capitol Cost	Annual O&M	Total Present Worth
\$10,024,000	\$159,200	\$12,430,000

The estimated cost of Alternative 4a is as follows:

Total Present Worth:	12,430,000
+ CND Disposal:	11,414,000
+ Mitigation:	5,250,000
= Total Cost:	\$29,094,000

Alternative 4b – Fill Area Removal to CSL and Capping

Alternative 4b consists of dredging the fill area to depths that achieve CSL criteria (thereby removing 98 percent of the mass of contaminants exceeding CSL criteria) and capping all remaining sediment (outside of the fill area) that exceeds these criteria. As with Alternative 4a, limited dredging would also be performed in the groundwater discharge zone and at the CMS terminal prior to capping.

A total of approximately 273,500 cubic yards of material would be dredged from the fill area and the CMS terminal area. Dredged sediments would be transported directly to a confined nearshore disposal (CND) site. If a CND site is not feasible, the dredged sediment would be disposed in a CAD facility or dewatered and placed in a newly constructed upland disposal facility. This decision would be made during remedial design.

A 3-foot cap would be placed over the approximately 24 acres of sediment exceeding CSL chemical criteria, requiring approximately 154,000 cubic yards of capping material. An additional 8,000 cubic yards of sediment would be required to establish a 5-foot cap over the intertidal areas. As with Alternatives 3a and 3b, capping would be done in stages over an approximate 3-year span based on the availability of clean, Puget Sound maintenance dredge material.

For fill area removal and capping to CSLs, the residual human health risks associated with the remediated site would be approximately in 2 in 10,000. The resulting non-cancer Hazard Index associated with the site would be 4.

The total cost of this alternative is approximately \$18,040,000 using the nearshore disposal option, \$11,170,000 using the CAD disposal option, and \$19,675,000 using a newly constructed upland disposal facility option. The following cost table summarizes the dredging and capping costs (see Table 31 for cost estimation assumptions):

Capitol Cost	Annual O&M	Total Present Worth
\$4,585,000	\$60,870	\$5,500,000

The estimated cost of Alternative 4b is as follows:

Total Present Worth:	5,500,000
+ CND Disposal:	8,190,000
+ Mitigation:	4,350,000
= Total Cost:	\$18,040,000

10. COMPARATIVE ANALYSIS OF ALTERNATIVES

This analysis addresses the Marine Sediments Unit alternatives.

10.1 Overall Protection of Human Health and the Environment

This criterion evaluates whether an alternative achieves and maintains adequate protection of human health and the environment. All of the alternatives except the "No Action" alternative would provide adequate protection by eliminating, reducing, or controlling risk through removal or containment, or a combination of the two. The relative degree of protectiveness has been determined by how clean the remaining surface sediment will be

following cleanup. The assumption that lower contaminant concentrations result in higher sediment quality was used to rank the alternatives for overall protection. The lowest degree of remaining surficial sediment contamination would be achieved through capping because clean sediment would be used. While dredging would remove any sediment that exceeded the cleanup goal, it would not remove all contaminated sediment down to the "native" or background level (i.e., the remaining sediment would not be as clean as what would be brought in for capping). The highest degree of protectiveness is provided by capping the contaminated sediment with clean sediment.

10.2 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

This criterion evaluates how each alternative complies with Federal and State statutes and regulations that pertain to the site. All alternatives, with the exception of the "No Action" alternative, comply with ARARs.

10.3 Long-Term Effectiveness and Permanence

This criterion evaluates the ability of an alternative to maintain protection of human health and the environment over time. Long-term effectiveness factors in the reliability of the remediation alternative and the degree of monitoring and maintenance that will be required. While all remediation alternatives, except the "No Action" alternative, provide long-term effectiveness and permanence (assuming current conditions), removing contaminated sediment and consolidating it in a disposal facility is more reliable than capping in place because removal and placement results in a smaller and more controlled area of contaminated sediment. In addition, an engineered disposal facility (specifically a nearshore fill or upland disposal site) is easier to inspect, monitor and maintain than a larger capped area in the aquatic environment. Alternatives with comparatively more dredging than capping rate higher under this criterion.

10.4 Reduction in Toxicity, Mobility and Volume Through Treatment

*This criterion evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present. None of the alternatives reduce toxicity, mobility or volume through treatment. Treatment was evaluated for sediment cleanup, however was screened out of further consideration for the following reasons: 1) there are currently no effective *in situ* treatments (i.e., treating in place) for sediments covering a large area or subjected to significant flushing, and 2) any *ex situ* treatment would require significant material handling (excavation, de-watering, transport, and processing) and extreme cost (estimated at \$40 million excluding material handling).*

10.5 Short-term Effectiveness

This criterion evaluates the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation. Short-term environmental impacts include water quality impacts, biota exposure and habitat loss (i.e., fisheries impacts) during the implementation of the remedial alternative. Dredging

alternatives would result in 1) greater water quality and fisheries impacts due to the disturbing and suspending of contaminated sediment, 2) greater worker exposure to contaminants due to the comparatively greater contaminated material handling, and 3) a slightly greater potential for worker injury resulting from the use of dredging machinery (more mechanically complex than capping equipment). Capping alternatives that would result in short-term loss of aquatic habitat due to covering the existing benthic community. Capping may also suspend contaminated sediment. It is important to note that much of the short-term risk associated with both dredging and capping can be significantly reduced by carefully choosing methodology and monitoring techniques. The duration of these short-term effects is generally proportional to an alternative's implementation period, including disruption of fisheries activities or other water-dependent uses. Capping generally has greater short-term effectiveness than dredging because it can be implemented more quickly. Alternative 3b for example, which is primarily capping, has an in-water implementation period of 11 months. Alternative 4b, which combines more dredging with capping has an in-water implementation period of 15 months. And, Alternative 2, which is primarily dredging has an in-water implementation period of 14 months. The time required to site and build a disposal facility to accommodate the larger volumes of dredge material is not included in the in-water estimates.

10.6 Implementability

This criterion evaluates the technical and administrative feasibility of implementing the alternative. Implementability includes the ease of construction, the availability and capacity of materials and/or facilities, and logistical and/or administrative practicability. Ease of construction is similar for dredging and capping. There are uncertainties associated with both technologies (i.e., for capping; material placement difficulties on slopes and at depth, and for dredging; material control concerns regarding dewatering and resuspension). Capping requires a volume of material that won't be available immediately and will require several years of maintenance dredging to procure. Similarly, dredging requires that a disposal facility be sited, which is a time-consuming and politically very difficult process. Placement of a cap would require moorage restrictions to ensure that anchors do not harm the cap and expose/distribute contaminated sediment. Due to the historically extreme difficulty in siting a disposal facility, the capping alternatives have an ultimately higher degree of implementability than dredging alternatives.

10.7 Cost

This criterion includes estimated capital and operation and maintenance costs as well as present worth costs. Cost estimates are expected to be accurate within a range of +50 to -30 percent. Current estimates indicate that capping is the least costly alternative, and dredging with its associated disposal costs is the most costly. See Table 25 for a summary of all the alternative's costs.

10.8 State Acceptance

This criterion evaluates whether the State of Washington agrees with the U.S. EPA's analyses and recommendations of the RI/FS and the Proposed Plan. The Washington State Department of Ecology concurs with EPA's Selected Remedy.

10.9 Community Acceptance

This criterion evaluates whether the local community agrees with U.S. EPA's analyses and preferred alternative. One phone call was received regarding the Proposed Plan for the PSR site. The caller left a message in support of the Preferred Alternative (and now the Selected Remedy). Many comments were received from State and Federal departments and agencies. Those comment and EPA's responses are included as Part 3, the Responsiveness Summary of this ROD.

11. SELECTED REMEDY

The Selected Remedy for the PSR site addresses both the Upland Unit and Marine Sediments Unit.

11.1 Upland Unit

Early cleanup actions were completed to address threats posed by contaminated soil and groundwater and shallow NAPL in the Upland Unit. Included in these actions were the installation of a subsurface containment wall and placement of a low-permeability surface cap over the Upland Unit. The early actions for soils and groundwater removed the most contaminated source material, eliminated direct contact with soils, eliminated soil transport to Elliott Bay, eliminated leaching of surface soil contaminants to groundwater, minimized potential future direct contact with subsurface soils, eliminated LNAPL discharges to Elliott Bay, minimized discharge of contaminated groundwater and DNAPL to Elliott Bay and significantly reduced the influence of tidal fluctuations at the site. The risk posed by exposure to contaminated soil has been eliminated, and groundwater meets cleanup requirements under the NCP and threshold requirements for cleanup actions under MTCA without implementation of additional engineered remedial measures. What was implemented as early action is final action for the Upland Unit. The Selected Remedy for the Upland Unit is:

- Inspection and Maintenance (I&M) of the surface cap; on both the Port of Seattle's intermodal yard working surface and the public access area. These actions will be in accordance with the I&M plans established during the early actions and contained in the Administrative Record.
- Monitoring groundwater contaminant concentrations and DNAPL volume trends. Alternate concentration limits have been established for PSR groundwater. These limits apply at the shoreline monitoring wells (see Table 20 for list of PSR ACLs). Groundwater will not impact Elliott Bay waters or sediment as long as these limits are met. EPA will evaluate additional remedial measures if groundwater monitoring trend analysis indicates these limits are being or will be exceeded. In addition, NAPL will continue to be

collected from on-site wells and disposed of in accordance with the RCRA Land Disposal Restriction treatment standards (i.e., incineration). A groundwater monitoring plan will be created and available for review prior to implementation. The estimated costs for Upland groundwater monitoring and NAPL collection are listed in Table 32.

- Institutional Controls for prohibiting groundwater use and restricting land use. The early actions will remain protective as long as the I&M plans are implemented and land and groundwater use are unchanged. Current land use is industrial with some controlled public access, and groundwater is not used at all. Record notification of these restrictions will be recorded against the property deed, and restrictive covenants ensuring conforming use will be required of any subsequent purchasers. The State has declared the groundwater to be non-potable; no drinking water wells will be permitted.

11.2 Marine Sediments Unit

The Selected Remedy for the Marine Sediments Unit is:

- Confinement (through capping) of contaminated marine sediments that exceed the CSL for PAHs or the SQS for PCBs (criteria are listed in Table 5). The SQS for PCB will be used to trigger cleanup for sediment at depths equal to or shallower than -10 feet MLLW. The capped area will encompass approximately 50 acres of contaminated sediment. The cap will physically isolate the contaminated marine sediment from the biological receptors (i.e., the benthic community, fish and humans), stabilize the sediment within the capped area to the extent practicable, and ensure that contaminant migration through the cap is effectively eliminated.
- The thickness of the cap will be determined through design studies (see following design discussion), however no less than 5 feet of clean material will be placed over the intertidal area.
- Dredging of approximately 3,500 cubic yards of contaminated sediment from the area to the north of Crowley Marine Services. The purpose of dredging this material is to maintain current navigational depths and access to Crowley Marine Services. The dredged material will be disposed of in an established upland solid waste landfill.
- Unused pilings throughout the Marine Sediments Unit will be removed prior to capping. The pilings will be cut at the mudline and clean cap material placed over the portion remaining in the sediment.
- The clean capping material used will be at least as clean or cleaner than the SQS and will be obtained from routine maintenance dredge projects in local rivers. In addition, capping material will be selected and placed in such a way as to provide appropriate habitat for the marine organisms natural to this area.
- Cap placement techniques will be determined during design (see following design discussion).
- The entire capped area will be designated as a "no-anchor" zone. The no-anchor designation will apply to commercial vessels using the large "whale-tail" type anchors that have the capacity to break through the cap and expose contaminated sediment. This

institutional control will be implemented through Federal rule-making by the U.S. Coast Guard and the Corps in consultation with the State Department of Natural Resources. The rule-making will be subject to public comment. MTCA Institutional Controls requirements will be met.

- Both a short- and long-term monitoring or management plan will be developed to ensure that the cap is placed as intended and is performing the basic confinement functions. Specific monitoring requirements will be included to address the intermediate groundwater discharge zone. The durations of the specific monitoring requirements will be addressed in the monitoring plan. In addition, this plan will address the monitoring approach to be implemented following any unusually significant seismic or storm event in the Elliott Bay area. The monitoring/management plan will also address data management, and contingency plans in the event the cap is not meeting the remedial objectives. These monitoring plans will be available for Natural Resource Agency's review prior to implementation.

11.3 Issues to be Addressed During the Design Phase of the Selected Remedy

As discussed above, several elements of the remedy will be evaluated during design:

- Cap thickness will be designed to physically isolate, stabilize and chemically isolate the contaminated marine sediments. This will be completed in accordance with the *Guidance for In Situ Subaqueous Capping of Contaminated Sediments* (EPA 905-B96-004). In addition, a determination will be made regarding whether additional engineered features are necessary to maintain the thicker cap in the nearshore area. If it is determined to be necessary, the remedial design will include these features.
- Cap placement techniques will be evaluated (and pilot test(s) conducted) to determine an optimized construction procedure (i.e., most efficient and least environmentally impacting) for placing clean material over the contaminated marine sediment to achieve the basic functions. The optimized construction procedure will take into account the geotechnical properties of both the *in situ* sediment and capping material, as well as the bathymetric configuration of the contaminated sediment (i.e., slope).

Figure 11 depicts the proposed marine sediments capping area, and capping cost estimation details are listed in tables 28 and 29.

The Total Present Worth Cost of the Selected Remedy is \$7,600,000.00. (This cost includes upland monitoring and marine capping. It does not include Upland I&M because those costs are anticipated to be borne by the Port of Seattle as part of their ongoing operation of the intermodal facility.)

The Selected Remedy will meet environmental and human health protection goals through controlled containment (i.e., capping) while leaving contamination in place. The decision to cap contaminated marine sediment is based in significant part on a cap's ability to meet the remedial action objectives at a lower cost than dredging and disposal alternatives. While capping will raise short-term water quality concerns, the potential for impacts is much lower than for alternatives that involve dredging large volumes of contaminated material. Another significant

factor against dredging large volumes of contaminated material is the historically extremely controversial and time-consuming process of siting an aquatic or nearshore disposal facility. The selected alternative does include dredging a small volume of contaminated sediment in order to maintain navigation, however this material can be disposed of in an established upland solid waste landfill. While the volume of material necessary to cap the contaminated sediment in the Marine Sediments Unit will not be available to allow the action to be completed in one season, this is less of a detriment than it might seem. Working with smaller portions of capping material over time will allow for trials of various placement techniques including an evaluation of comparative capping efficacy and durability.

11.4 Estimated Outcomes of the Selected Remedy

The Selected Remedy will greatly reduce the environmental impacts associated with the current sediment contamination because the material used for capping will have contaminant concentrations equivalent to or lower than background Elliott Bay concentrations. Human health risk will be reduced by an order of magnitude. This alternative has relatively minimal impacts to fisheries and other water-dependant industries because it can be completed without extended periods of in water work, and without reduction of the fishery area. The implementation period for this alternative is nearly 4 years due to limited capping material available each year, however the short-term impacts are minimal and do not persist through the entire period (i.e., only during intermittent capping phases).

12. STATUTORY DETERMINATIONS

Based on information currently available, EPA and Ecology believe the Selected Remedy provides the best balance of tradeoffs among the alternatives with respect to the evaluation criteria. The EPA expects the Preferred Alternative to satisfy the statutory requirement in CERCLA section 121(b) to: 1) be protective of human health and the environment; 2) comply with ARARs; 3) be cost-effective; 4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element.

Under CERCLA Section 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements, are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

12.1 Protection of Human Health and the Environment:

The Selected Remedy will be protective of human health and the environment. Implementation of the I&M plans, monitoring plans and institutional controls for the Upland Unit will ensure that the protection provided by the early actions is maintained. Placement of

clean cap material over the contaminated sediments will isolate the contaminants from the environment. The benthic community will have clean substrate to colonize, and fish and shellfish (the route to human exposure) will no longer be subjected to contaminated sediment in the area of the cap. In addition, bottom fish and anadromous fish will benefit from improved habitat in the nearshore area. Human health risk will be reduced by an order of magnitude (from $4.5\text{E-}04$ to $4.2\text{E-}05$ for the reasonable maximally exposed individual). The background risk calculated for Elliott Bay is $2.9\text{E-}05$, so the Selected Remedy will reduce the risk associated with the site to essentially urban background levels. Implementation of this remedy may create some short-term risk to the environment through resuspension of contaminated sediment, however design studies as well as practice with various placement techniques will be utilized to minimize any short term impacts.

12.2 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

The Selected Remedy will comply with all applicable or relevant and appropriate requirements as follows:

12.2.1 Upland Unit ARARs

State Model Toxics Control Act

- | | |
|--------------------------|--|
| (WAC 173-340-720(1)(C)) | This is applicable to establishing cleanup levels for groundwater. |
| (WAC 173-340-440) | This is applicable to establishing institutional controls. |
| (WAC 173-340-730(3)) | This is applicable to establishing cleanup standards for surface water. (These standards are currently being met.) |
| (WAC 173-340-360(4),(6)) | This is applicable to cleanup technologies and restoration timeframes. |
| (WAC 173-340-704 -706) | This is applicable to the use of Method A, B, and C. |

12.2.2 Marine Sediments Unit ARARs

State Model Toxics Control Act

- | | |
|-------------------|--|
| (WAC 173-340-440) | This is applicable to establishing institutional controls. |
|-------------------|--|

Federal Water Pollution Control Act/Clean Water Act (33 USC 1251-1376; 40 CFR 100-149)

Acute marine criteria are anticipated to be relevant and appropriate requirements for discharge to marine surface water during cap placement and sediment dredging.

Washington State Water Quality Standards for Surface Waters (WAC 173-201A)

Standards for the protection of surface water quality have been established in Washington state. The standards for marine waters will be applicable to discharges to surface water during cap placement and sediment dredging.

Washington Sediment Management Standards (WAC 173-204)

Chemical concentration and biological effects criteria are established for Puget Sound sediment and are applicable to PSR sediment cleanup. Sediment cleanup standards are established on a site-specific basis from a range of concentrations.

State Water Pollution Control Act (RCW 90.48)/Water Resources Act (RCW 90.54)

Requirements for the use of all known, available and reasonable technologies for treating wastewater prior to discharge to state waters are applicable to any dewatering of marine sediment prior to upland disposal. Section 401 requires certification for activities conducted under 404 authorities. The substantive requirements of a certification determination are applicable.

Construction in State Waters, Hydraulic Code Rules (RCW 75.20; WAC 220-110)

Hydraulic project approval and associated requirements for construction projects in state waters have been established for the protection of fish and shellfish. Substantive permit requirements are applicable to cap placement. The technical provisions and timing restrictions of the Hydraulic Code Rules are applicable to cap placement and dredging.

State Discharge Permit Program/NPDES Program (WAC 173-216, -220)

The Washington state NPDES program provides conditions for authorizing direct discharges to surface waters and specifies point source standards for such discharges. These standards are applicable to discharges to surface waters resulting from sediment dewatering operations during dredging/disposal work.

Federal Clean Water Act Dredge and Fill Requirements; Sections 401 and 404 (33 USC 401 et seq. 33 USC 1251-1316; 33 USC 1413; 40 CFR 230, 231; 33 CFR 320-330)

These regulations provide requirements for the discharge of dredged or fill material to waters of the U.S. and are applicable to any in-water work. The 404 evaluation is complete and is included in the Administrative Record for the PSR site. The Finding was that this project complies with the requirements.

Federal Endangered Species Act of 1973 (16 USC 1531 et seq., 50 CFR Part 200, 402)

This regulation is applicable to any remedial actions performed at this site as this area is potential habitat for threatened and/or endangered species.

Rivers and Harbors Appropriations Act (33 USC 403, 33 CFR 322)

Section 10 of this act establishes permit requirements for activities that may obstruct or alter a navigable waterway; activities that could impede navigation and commerce are prohibited. These substantive permit requirements are anticipated to be applicable to remedial actions, such as dredging and capping, which may affect the navigable portions of the harbor.

U.S. Fish and Wildlife Coordination Act (16 USC 661 et seq.)

Elliott Bay shorelines provide potential habitat for bald eagles and other avian species, and Marine Sediments Unit surface water is used as a salmonid migratory route. This act prohibits water pollution with any substance deleterious to fish, plant life, or bird life, and requires consultation with the U.S. Fish and Wildlife Service and appropriate state agencies. Criteria are established regarding site selection, navigational impacts, and habitat remediation. The act also requires that fill material on aquatic lands be stabilized to prevent washout. These requirements are anticipated to be relevant and appropriate for remedial activities on the site.

Resource Conservation and Recovery Act (40CFR Part 261.4(g))

This regulation is an exemption determining dredged contaminated sediments that are subject to the requirements of Section 404 of the Clean Water Act are not RCRA hazardous waste.

Shoreline Management Act (RCW 90.58, WAC 173-14); Coastal Zone Management Act (16 USC 1451 et seq., 15 CFR 923)

This statute is relevant and appropriate for capping activities in the shoreline area..

State Aquatic Lands Management Laws (RCW 79.90-79.96, WAC 332-30)

The final remedy must be consistent with state laws that promote environmental protection, public access, water dependent uses, and uses of renewable resources and that generate revenue to the state in a manner consistent with these management goals.

To Be Considered (TBCs)

TBC items are state and local ordinances, advisories, guidance documents or other requirements that, although not ARARs, may be used in determining the appropriate extent and manner of cleanup. Generally, TBC requirements are used when no federal or state requirements exist for a particular situation. A list of TBCs for PSR Marine Sediments Unit remediation is presented in Table 24.

12.3 Cost-Effectiveness

In EPA's judgment, the Selected Remedy is cost effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was

used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness". (NCP 300.430(f)(ii)(D)). Alternative 3 provides greater protection of human health and the environment than the other alternatives that meet the same cleanup goal, at a lower cost. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money to be spent.

12.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at this site. The Selected Remedy treats the upland source materials constituting principal threats at the site, achieving reduction in NAPL volume in soil and groundwater. NAPL will be targeted for collection as a component of the on-going monitoring of this site. All NAPL collected will be incinerated. Approximately 1,500 gallons of NAPL has been collected and incinerated to date.

12.5 Preference for Treatment as a Principal Element

Treatment of contaminated sediment to reduce toxicity or mobility of contaminants is not considered feasible. As stated previously, treatment was evaluated for sediment cleanup, however was not considered further for the following reasons: 1) there are currently no effective *in situ* treatments (i.e., treating in place) for sediments covering a large area and subjected to significant flushing, and 2) any *ex situ* treatment would require significant material handling (excavation, de-watering, transport, and processing) and extreme cost (estimated at \$40 million excluding material handling).

12.6 Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

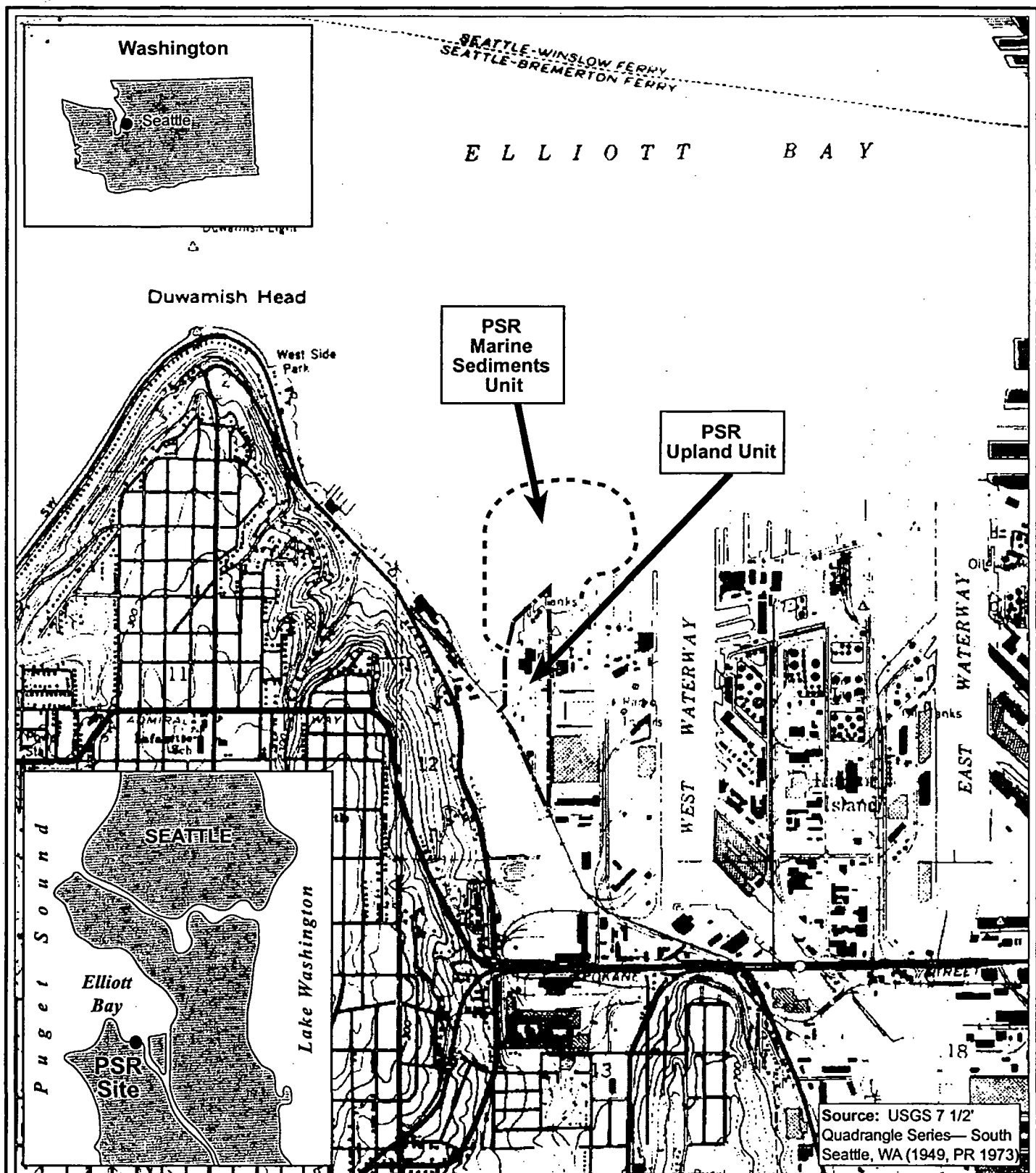
12.7 Documentation of Significant Changes from Preferred Alternative of Proposed Plan

The Proposed Plan was released for public comment in April 1999. It identified Alternative 3b, placement of a marine cap, as the Preferred Alternative for sediment remediation. The Preferred Alternative specified that a small volume of material would be dredged to allow for continued navigational access to Crowley Marine Services, and the dredged material would be placed within the area to be capped, then capped with the rest of the contaminated sediment. Comment was received urging the use of an upland disposal site rather than replacement of the dredged material back into the marine environment. EPA made this change in the Selected Remedy. In addition, the Preferred Remedy as described in the Proposed Plan specified that institutional controls would be implemented in the nearshore area to restrict shellfish harvesting. The beach area that could be utilized for shellfish harvest is only available about 70 days of the

year (i.e. at low tides) and access to the beach is very limited (its only accessible by boat). Public comment indicated that institutional controls of this nature would impact tribal treaty rights. EPA has revised the Selected Remedy to include placement of additional clean material in the nearshore area (no less than 5 feet) which will allow for unrestricted harvest of shellfish.

These changes could have been reasonably anticipated based on the information in the Proposed Plan. Therefore, the procedural requirement is met by discussing these changes in this ROD.

FIGURES

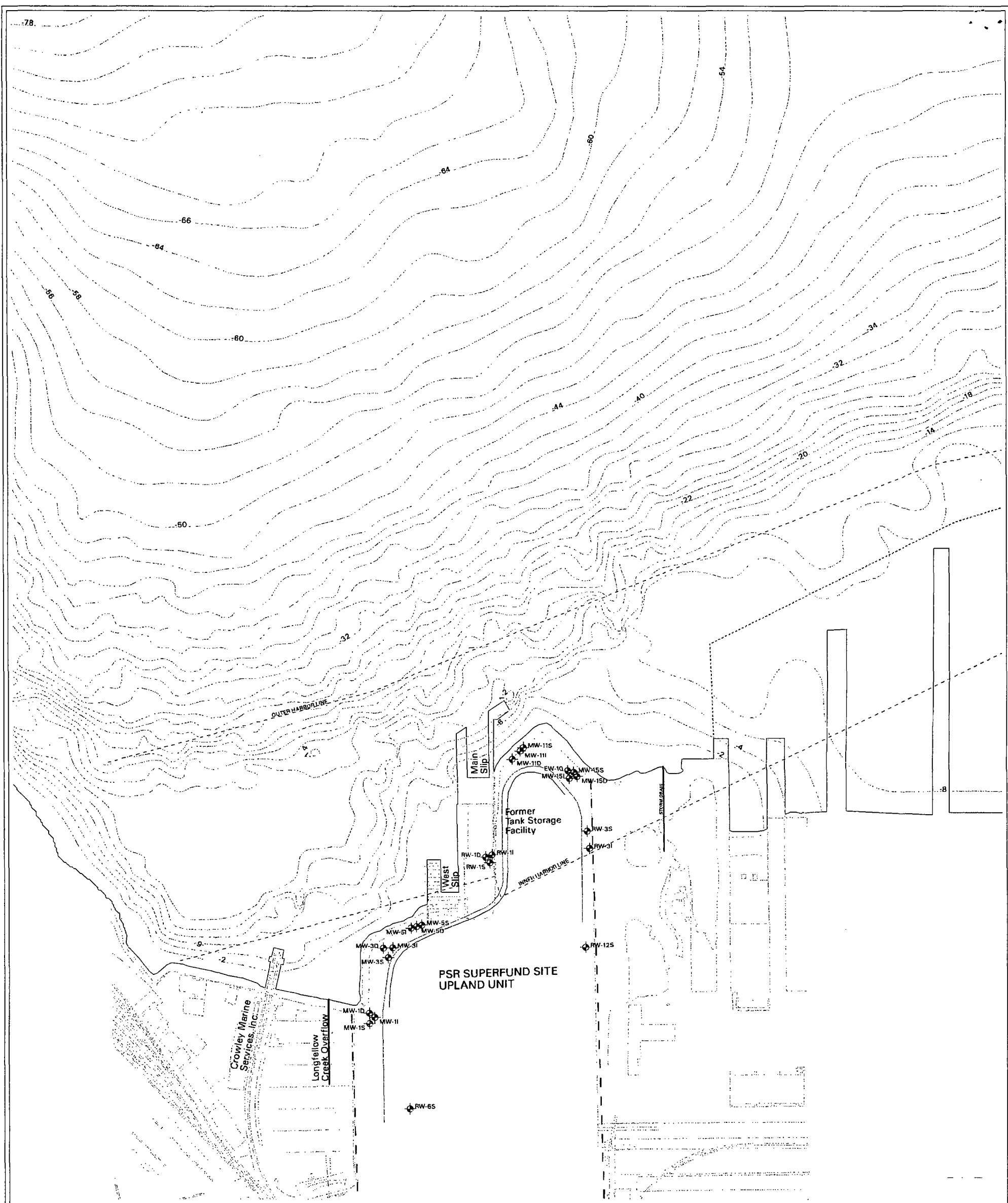


WESTON
MANAGER DESIGNERS/CONSULTANTS

PSR Upland and Marine Sediments Unit Location Map

Figure

1

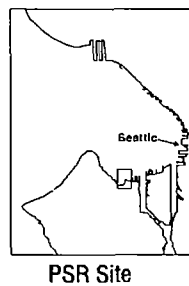
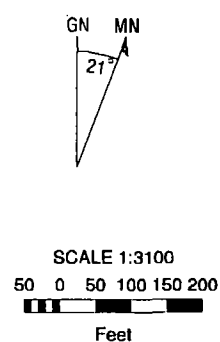


BASEMAP EXPLANATION

- Upland Feature
- Shoreline
- Upland Unit Property Boundary
- Bathymetry
- Drain
- Harbor Line
- Slurry Wall
- LNAPL Recovery Trench
- Lockheed cleanup action plan boundary

SYMBOL EXPLANATION

- Upland groundwater monitoring well
- Capped Area (See also Note 4)



NOTES

- 1) Vertical datum is: Meters Mean Lower Low Water (MLLW).
- 2) Bathymetric data source: NOAA, 1970 & 1995.
- 3) Locations of slurry wall, LNAPL trench, and monitoring wells approx. (RETEC, 1996a, 1996b).
- 4) Areas not capped with asphalt will be covered with clean fill and landscaping.
- 5) Intertidal area (pocket beaches) defined by -1 m MLLW contour (not shown).



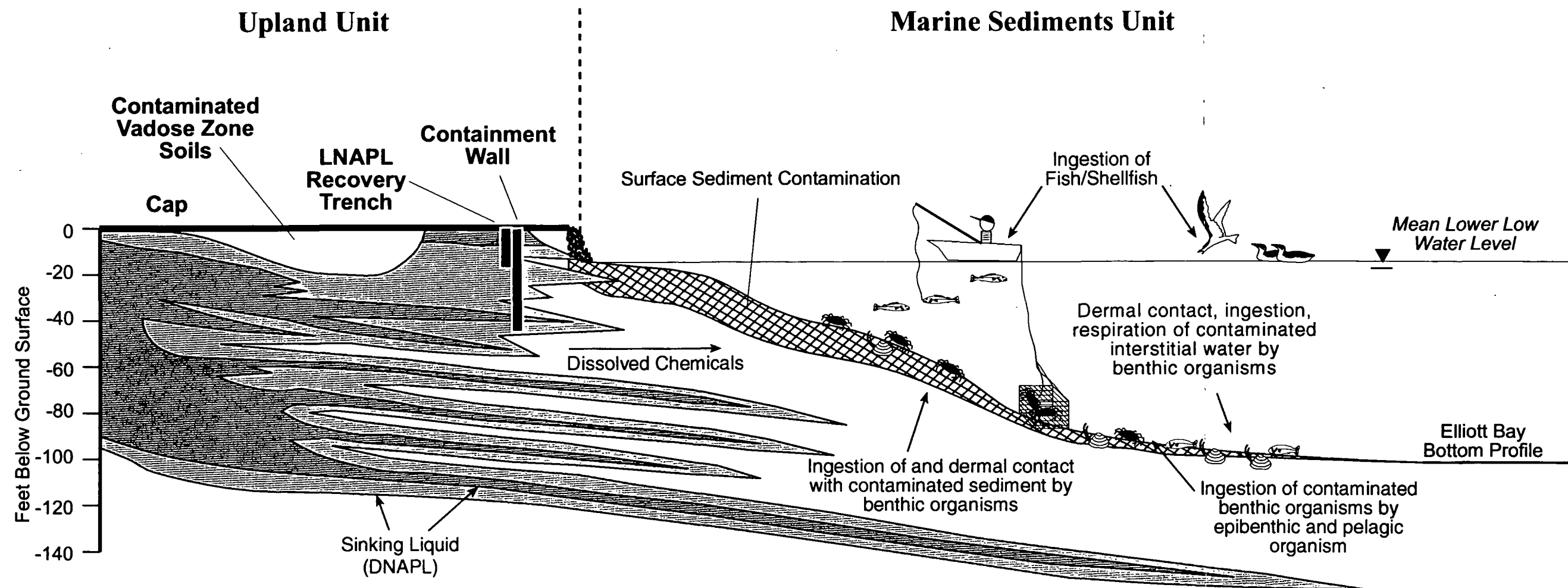
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VIEW FILE: basemap.view

CHECKED BY: _____
APPROVED BY: _____

PSR Upland and Marine Sediments Unit Site Features

**Region 10
Superfund Records Center**

1101693






EXPLANATION

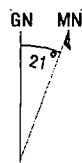
- Residual NAPL
- Dissolved Phase NAPL
- Fill Area



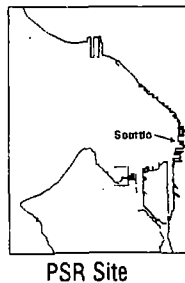
EXPLANATION

-  Intermediate groundwater discharge zone associated with west-central shoreline wells containing DNAPL.
-  Crowley Marine barge moorage area.

-  Area where additional cap material is required to support shell fishing.



SCALE 1:2000
50 0 50 100 150 200
Feet



PSR Site

NOTES



DATE: March 09, 1998 1:44 PM
JOB NUMBER: 98-0582
VIEW FILE:

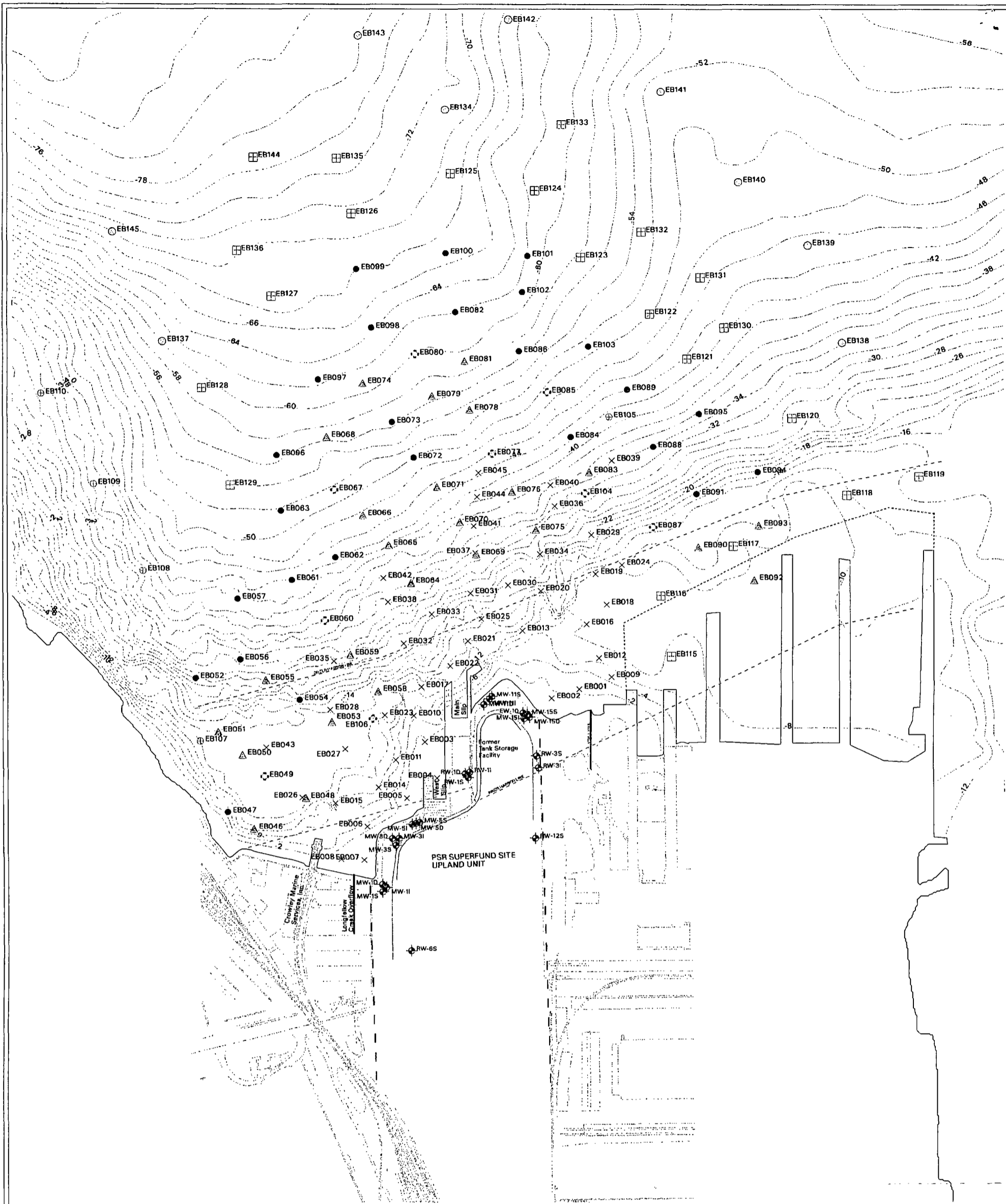
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PSR Marine Sediments Unit Shoreline Cap Area

FIGURE
4

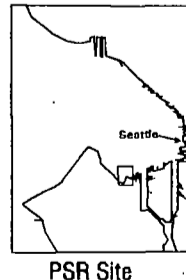
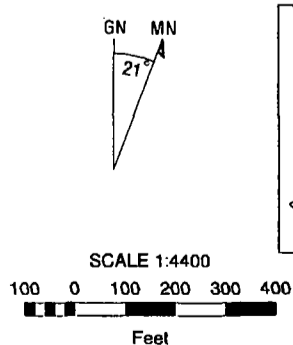
**Region 10
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SYMBOL EXPLANATION

- Phase 3 Surface (0 - 10 cm) Sediment Collected for Analysis (n = 22)
- Phase 3 Surface Sediment Collected for Archival (n = 9)
- ⊕ Phase 2 Surface (0 to 10 cm) Sediment Station - Chemistry Only (n = 7)
- ◆ Phase 2 Sediment Triad Station - Bioassays, Benthos, Surface (0 to 10 cm) Chemistry (n = 9)
- Phase 2 Surface (0 to 10 cm) Sediment Station - Chemistry and/or Field Immunoassays (n = 26)
- ▲ Phase 2 Surface (0 to 10 cm) Sediment Station - Field Immunoassay Only (n = 25)
- × Phase 1 Surface (0 to 10 cm) Sediment Sample - Chemistry Only (n = 45)



NOTES

- 1) See Figure 2 for site feature notes and global symbols.
- 2) Phase 2 Recon. stations EB111 and EB112 are located northwest of EB110.
- 3) Stations EB115 and EB092 located within the Lockheed cleanup action plan boundary.



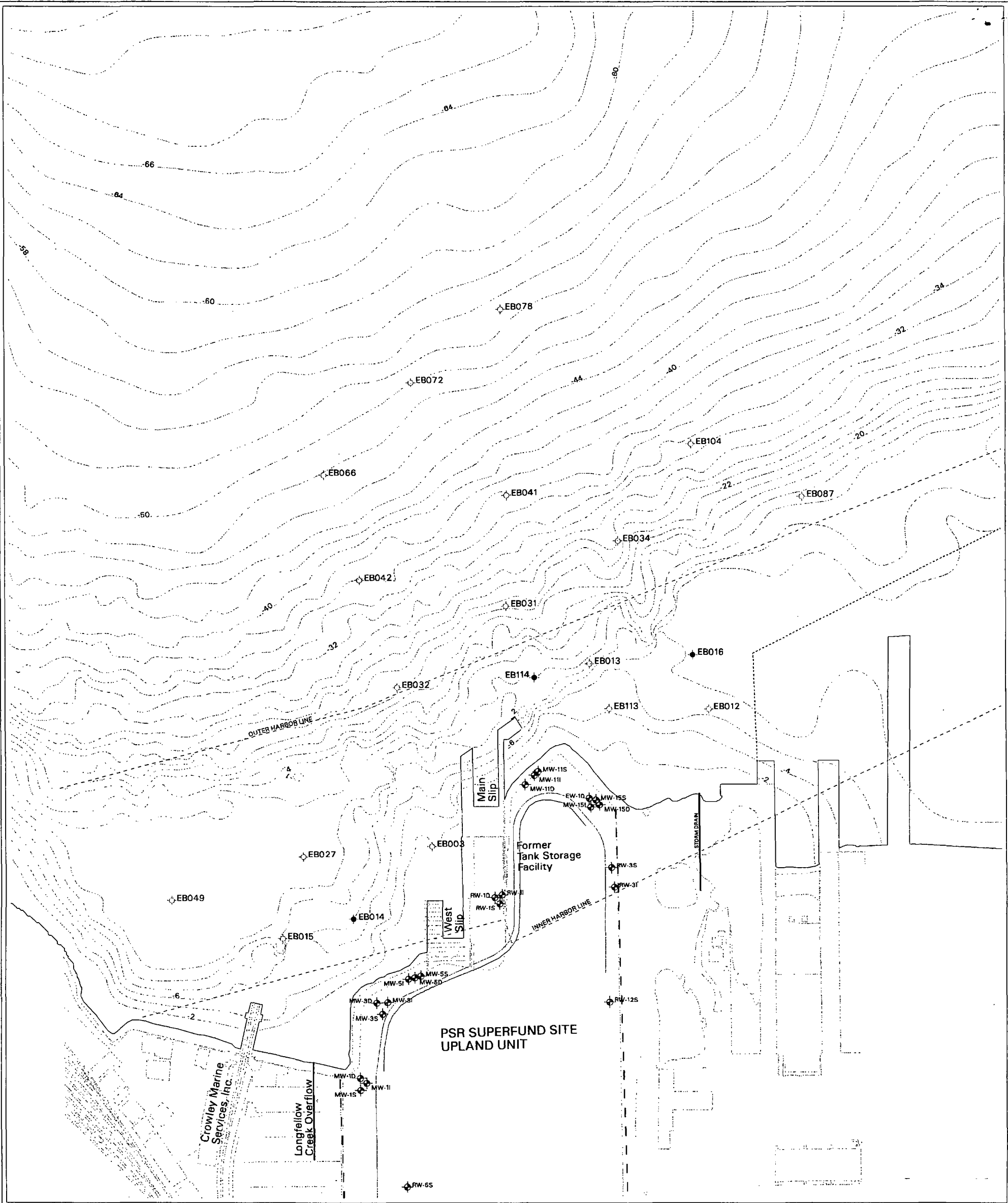
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VIEW FILE: allstns.view

CHECKED BY: _____
APPROVED BY: _____

PSR Marine Sediments Unit Phase 1, 2, and 3 Surface Sediment Chemical and Biological Sampling Locations

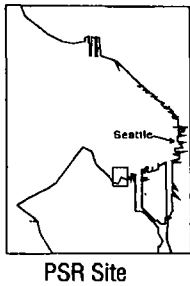
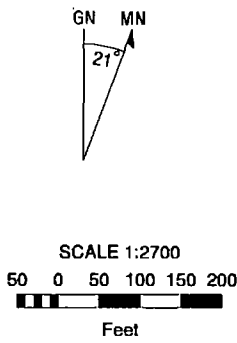
**Region 10
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SYMBOL EXPLANATION

- ◇ Shallow (0 to 20 ft) Subsurface Sediment Core (n = 17)
- ◆ Deep (0 to 96 ft) Subsurface Sediment Core (n = 3)



PSR Site

NOTES

- 1) See Figure 2 for site feature notes and global symbols.
- 2) Refusal encountered at four stations as follows:
 EB012: 12 ft below mudline
 EB042: 8 ft below mudline
 EB072: 19 ft below mudline
 EB113: 7 ft below mudline



DATE: September 28, 1999 3:23 PM
 JOB NUMBER: 12240-043-001-0134
 VIEW FILE: subsurface.view

CHECKED BY: _____
 APPROVED BY: _____

PSR Marine Sediments Unit Phase 2 Subsurface Sediment Sampling Locations

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110 1693

•BK001
BK001D

Magnolia
Bluff

Terminal 91

Smith
Cove

Myrtle Edwards
Park

BK002^Δ

Elliott Bay

Duwamish Head

Alki

•BK004

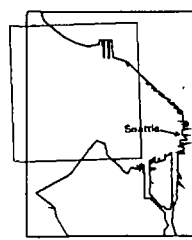
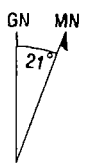
BK003^Δ

PSR

BASEMAP EXPLANATION

NOTES

1) Carr Inlet reference station not shown.



SCALE 1:22000
500 0 500 1000 1500 2000
Feet

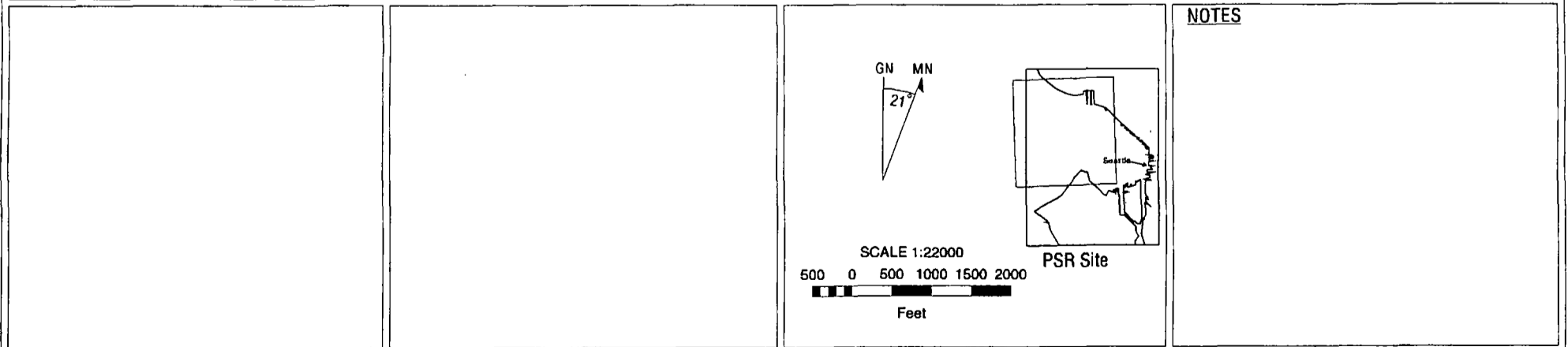
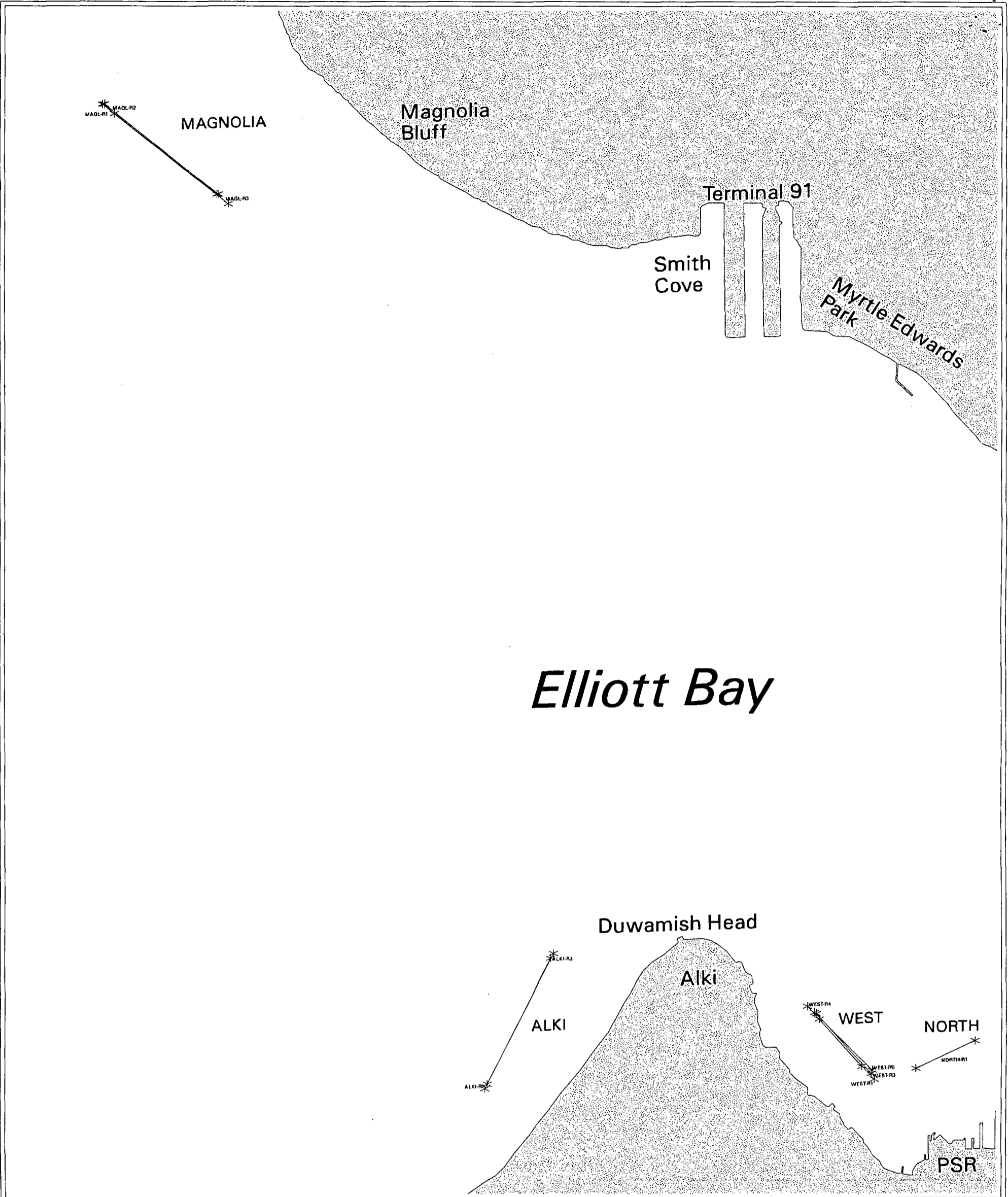


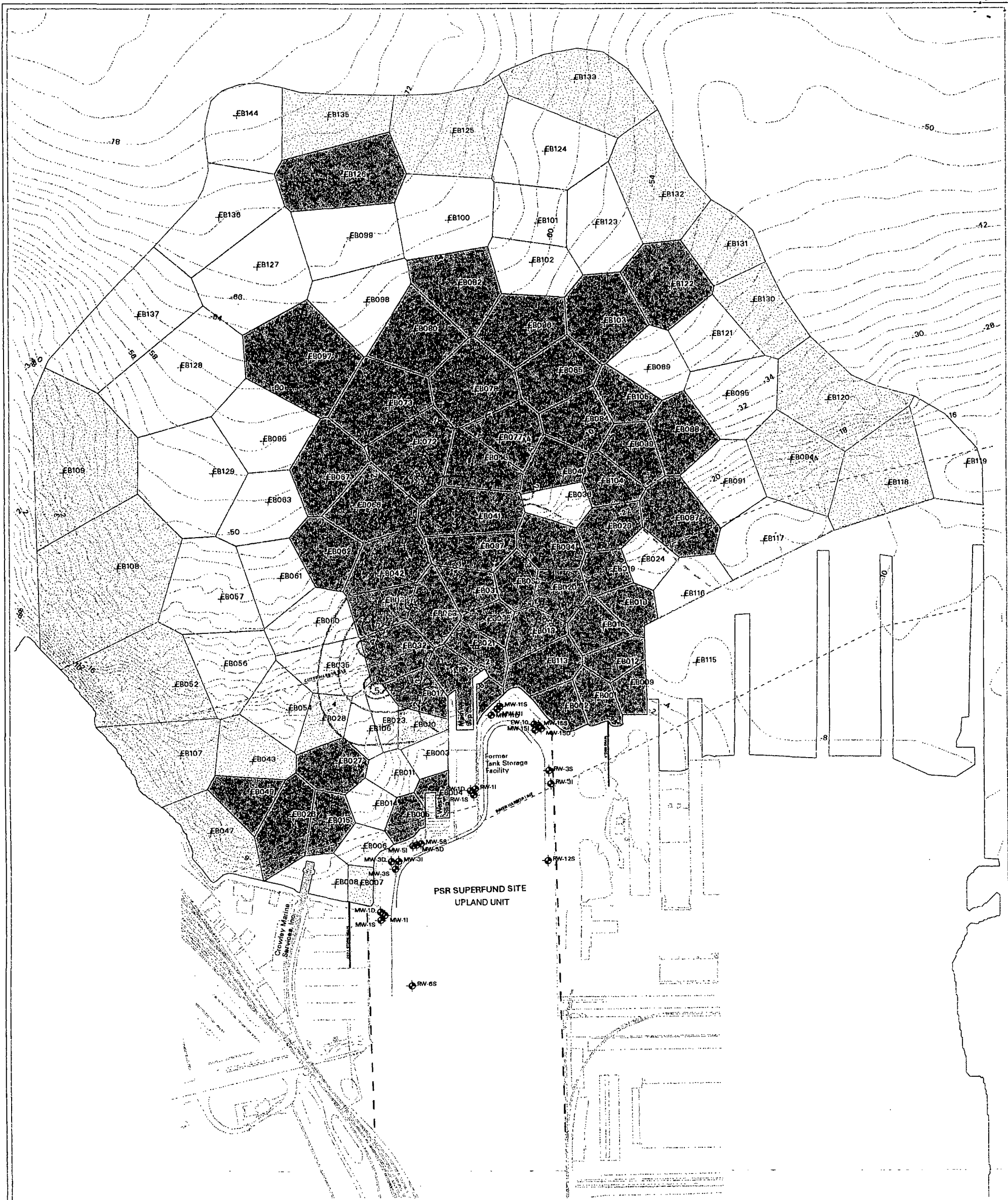
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

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
PSR Marine Sediments Unit
Surface Sediment Background
Chemical and Triad Sampling
Locations

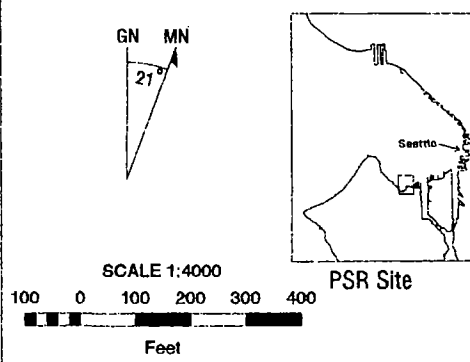
Figure
7





 Potential Fill Thickness in Meters
 Extrapolated Fill Boundary

SYMBOL EXPLANATION
 Below TOCN SQS or LAET
 Above TOCN SQS or LAET
 Above TOCN CSL or 2LAET
 Impermeable Cap



NOTES
 See Figure 2 for site feature notes and global symbols.
 1) Exceedances based on individual or group totals for PAHs.
 2) fill contours from USGS sub-bottom profiling data (1996).

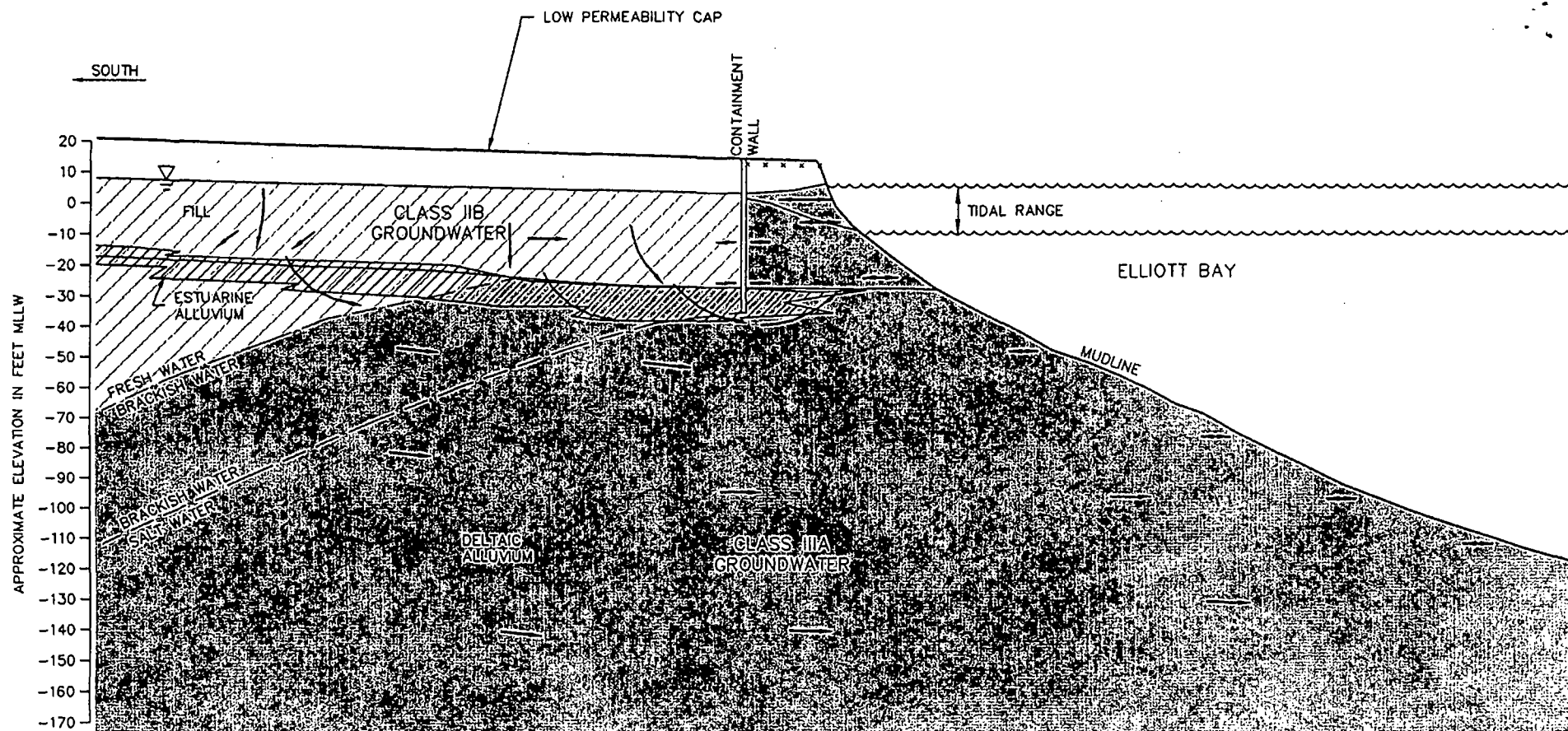


DATE: September 22, 1999 2:01 PM
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PSR Marine Sediment Unit Surface Sediment PAH Exceedance¹ Areas and Fill Contours²

**Region 10
Superfund Records Center**

1101693



NOTES

1. SCALE AND ELEVATIONS ARE APPROXIMATE. HIGH AND LOW TIDE LEVELS AND SURFACE RELIEF ARE ESTIMATED.
2. OUTSIDE THE CONTAINMENT WALL, SALT WATER IS EXPECTED DUE TO TIDAL FLUCTUATIONS THAT WILL OVERWHELM ANY FRESHWATER FLOW.

0 65 130 260

APPROXIMATE HORIZONTAL SCALE IN FEET
VERTICAL SCALE: 1" = 40'

LEGEND

→ GROUNDWATER FLOW DIRECTION
MLLW MEAN LOWER LOW WATER

Source: Port of Seattle: Pacific Sound Resources
-RA4SWHP (3-1335-564)

Approximate Location of Saltwater-Freshwater Interface Pacific Sound Resources-Superfund Site



Figure
10

TABLES

1101 693

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 1—Summary of Surface Sediment Chemical and Biological Analyses

Sample Number		Field Analysis ^a	Physical and Chemical Analysis ^b							Biological Analysis ^c		
Weston ID	EPA ID	Immunoassay	TOC	Grain Size	% Moisture	PAHs ^d	PCBs ^e	PCDD/PCDF	Metals ^f	Bioassays ^g	Bioaccum	Benthos
PSR Marine Sediments Unit												
SD1-EB01-0000	96162600	--	X	X	X	X	--	--	X	--	--	--
SD1-EB02-0000	96162601	--	X	X	X	X	X	X	X	--	--	--
SD1-EB03-0000	96162602	--	X	X	X	X	--	--	X	--	--	--
SD1-EB04-0000	96162603	--	X	X	X	X	--	--	X	--	--	--
SD1-EB05-0000	96162604	--	X	X	X	X	X	X	X	--	--	--
SD1-EB06-0000	96162605	--	X	X	X	X	X	--	X	--	--	--
SD1-EB07-0000	96162606	--	X	X	X	X	X	X	X	--	--	--
SD1-EB08-0000	96162607	--	X	X	X	X	X	--	X	--	--	--
SD1-EB09-0000	96162608	--	X	X	X	X	--	--	X	--	--	--
SD1-EB10-0000	96162609	--	X	X	X	X	X	X	X	--	--	--
SD1-EB11-0000	96162610	--	X	X	X	X	X	--	X	--	--	--
SD1-EB12-0000	96162611	--	X	X	X	X	X	X	X	--	--	--
SD1-EB13-0000	96162612	--	X	X	X	X	--	--	X	--	--	--
SD1-EB14-0000	96162613	--	X	X	X	X	X	X	X	--	--	--
SD1-EB15-0000	96162614	--	X	X	X	X	X	X	X	--	--	--
SD1-EB16-0000	96162615	--	X	X	X	X	X	X	X	--	--	--
SD1-EB17-0000	96162616	--	X	X	X	X	X	X	X	--	--	--
SD1-EB18-0000	96162617	--	X	X	X	X	--	--	X	--	--	--
SD1-EB19-0000	96162618	--	X	X	X	X	--	--	X	--	--	--
SD1-EB20-0000	96162619	--	X	X	X	X	--	--	X	--	--	--
SD1-EB20-1000	96162620	--	X	X	X	X	--	--	X	--	--	--
SD1-EB21-0000	96162621	--	X	X	X	X	--	--	X	--	--	--
SD1-EB22-0000	96162622	--	X	X	X	X	--	--	X	--	--	--
SD1-EB23-0000	96162623	--	X	X	X	X	X	X	X	--	--	--
SD1-EB24-0000	96162624	--	X	X	X	X	X	X	X	--	--	--
SD1-EB25-0000	96162625	--	X	X	X	X	--	--	X	--	--	--
SD1-EB26-0000	96162626	--	X	X	X	X	X	X	X	--	--	--
SD1-EB27-0000	96162627	--	X	X	X	X	X	NA	X	--	--	--
SD1-EB28-0000	96162628	--	X	X	X	X	X	X	X	--	--	--
SD1-EB29-0000	96162629	--	X	X	X	X	X	X	X	--	--	--
SD1-EB30-0000	96162630	--	X	X	X	X	X	X	X	--	--	--
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SD1-EB32-0000	96162632	--	X	X	X	X	X	X	X	--	--	--
SD1-EB33-0000	96162633	--	X	X	X	X	X	X	X	--	--	--

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 1—Summary of Surface Sediment Chemical and Biological Analyses

Sample Number		Field Analysis ^a	Physical and Chemical Analysis ^b							Biological Analysis ^c		
Weston ID	EPA ID	Immunoassay	TOC	Grain Size	% Moisture	PAHs ^d	PCBs ^e	PCDD/PCDF	Metals ^f	Bioassays ^g	Bioaccum	Benthos
SD1-EB34-0000	96162634	--	X	X	X	X	X	X	X	--	--	--
SD1-EB35-0000	96162635	--	X	X	X	X	X	X	X	--	--	--
SD1-EB36-0000	96162636	--	X	X	X	X	X	X	X	--	--	--
SD1-EB37-0000	96162637	--	X	X	X	X	X	X	X	--	--	--
SD1-EB38-0000	96162638	--	X	X	X	X	X	X	X	--	--	--
SD1-EB39-0000	96162639	--	X	X	X	X	X	X	X	--	--	--
SD1-EB39-1000	96162640	--	X	X	X	X	X	X	X	--	--	--
SD1-EB40-0000	96162641	--	X	X	X	X	X	X	X	--	--	--
SD1-EB41-0000	96162642	--	X	X	X	X	X	X	X	--	--	--
SD1-EB42-0000	96162643	--	X	X	X	X	X	X	X	--	--	--
SD1-EB43-0000	96162648	--	X	X	X	X	X	X	X	--	--	--
SD1-EB44-0000	96162649	--	A	A	A	A	A	A	A	--	--	--
SD1-EB45-0000	96162650	--	X	X	X	X	X	X	X	--	--	--
SD2-EB46-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB47-0000	96382524	X	X	X	--	X	--	--	--	--	--	--
SD2-EB48-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB49-0000	96382526	X	X	X	--	X	X	X	X ^h	X	X	X
SD2-EB50-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB51-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB52-0000	96364550	X	X	--	--	X	--	--	--	--	--	--
SD2-EB53-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB54-0000	96382527	X	X	X	--	X	--	--	--	--	--	--
SD2-EB54-1000	96382525	X	X	X	--	X	--	--	--	--	--	--
SD2-EB55-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB56-0000	96392701	X	X	--	--	X	--	--	--	--	--	--
SD2-EB57-0000	96382528	X	X	X	--	X	--	--	--	--	--	--
SD2-EB58-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB59-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB60-0000	96382529	X	X	X	--	X	X	X	X ^h	X	X	X
SD2-EB61-0000	96364551	X	X	--	--	X	--	--	--	--	--	--
SD2-EB62-0000	96392702	X	X	--	--	X	--	--	--	--	--	--
SD2-EB63-0000	96382530	X	X	X	--	X	--	--	--	--	--	--
SD2-EB64-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB65-0000	--	X	--	--	--	--	--	--	--	--	--	--
SD2-EB66-0000	--	X	--	--	--	--	--	--	--	--	--	--

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 1—Summary of Surface Sediment Chemical and Biological Analyses

Sample Number		Field Analysis ^a	Physical and Chemical Analysis ^b							Biological Analysis ^c		
Weston ID	EPA ID	Immunoassay	TOC	Grain Size	% Moisture	PAHs ^d	PCBs ^e	PCDD/PCDF	Metals ^f	Bioassays ^g	Bioaccum	Benthos
SD2-EB67-0000	96382531	X	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB68-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB69-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB70-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB71-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB72-0000	96382532	X	X	X	—	X	—	—	—	—	—	—
SD2-EB73-0000	96392703	X	X	—	—	X	—	—	—	—	—	—
SD2-EB74-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB75-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB76-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB77-0000	96382533	X	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB78-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB79-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB80-0000	96382534	X	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB81-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB82-0000	96392704	X	X	—	—	X	—	—	—	—	—	—
SD2-EB83-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB84-0000	96392705	X	X	—	—	X	—	—	—	—	—	—
SD2-EB85-0000	96382535	X	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB86-0000	96382536	X	X	X	—	X	—	—	—	—	—	—
SD2-EB87-0000	96382537	X	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB88-0000	96392706	X	X	—	—	X	—	—	—	—	—	—
SD2-EB89-0000	96364552	X	X	—	—	X	—	—	—	—	—	—
SD2-EB90-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB91-0000	96382538	X	X	X	—	X	—	—	—	—	—	—
SD2-EB92-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB93-0000	—	X	—	—	—	—	—	—	—	—	—	—
SD2-EB94-0000	96364554	X	X	—	—	X	—	—	—	—	—	—
SD2-EB95-0000	96364553	X	X	—	—	X	—	—	—	—	—	—
SD2-EB96-0000	96374565	X	X	—	—	X	—	—	—	—	—	—
SD2-EB97-0000	96382539	X	X	X	—	X	—	—	—	—	—	—
SD2-EB98-0000	96374566	X	X	—	—	X	—	—	—	—	—	—
SD2-EB99-0000	96374567	X	X	—	—	X	—	—	—	—	—	—
SD2-EB100-0000	96382540	X	X	X	—	X	—	—	—	—	—	—
SD2-EB101-0000	96374568	X	X	—	—	X	—	—	—	—	—	—

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 1—Summary of Surface Sediment Chemical and Biological Analyses

Sample Number		Field Analysis ^a	Physical and Chemical Analysis ^b							Biological Analysis ^c		
Weston ID	EPA ID	Immunoassay	TOC	Grain Size	% Moisture	PAHs ^d	PCBs ^e	PCDD/PCDF	Metals ^f	Bioassays ^g	Bioaccum	Benthos
SD2-EB102-0000	96374569	X	X	—	—	X	—	—	—	—	—	—
SD2-EB103-0000	96374570	X	X	—	—	X	—	—	—	—	—	—
SD2-EB104-0000	96382541	—	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB105-0000	96382542	—	X	X	—	X	—	—	—	—	—	—
SD2-EB106-0000	96382543	—	X	X	—	X	X	X	X ^h	X	X	X
SD2-EB107-0000	96382544	—	X	X	—	X	—	—	—	—	—	—
SD2-EB108-0000	96382547	—	X	X	—	X	—	—	—	—	—	—
SD2-EB109-0000	96382548	—	X	X	—	X	—	—	—	—	—	—
SD2-EB110-0000	96382549	—	X	A	—	A	—	—	—	—	—	—
SD2-EB111-0000	96382550	—	X	A	—	A	—	—	—	—	—	—
SD2-EB112-0000	96382551	—	X	A	—	A	—	—	—	—	—	—
SD3-EB115-0000	97312350	—	X	—	—	X	—	—	—	—	—	—
SD3-EB116-0000	97312351	—	X	—	—	X	—	—	—	—	—	—
SD3-EB117-0000	97312352	—	X	—	—	X	—	—	—	—	—	—
SD3-EB118-0000	97312353	—	X	—	—	X	—	—	—	—	—	—
SD3-EB119-0000	97312354	—	X	—	—	X	—	—	—	—	—	—
SD3-EB120-0000	97312355	—	X	—	—	X	—	—	—	—	—	—
SD3-EB121-0000	97312356	—	X	—	—	X	—	—	—	—	—	—
SD3-EB122-0000	97312357	—	X	—	—	X	—	—	—	—	—	—
SD3-EB123-0000	97312358	—	X	—	—	X	—	—	—	—	—	—
SD3-EB124-0000	97312359	—	X	—	—	X	—	—	—	—	—	—
SD3-EB125-0000	97312360	—	X	—	—	X	—	—	—	—	—	—
SD3-EB126-0000	97312361	—	X	—	—	X	—	—	—	—	—	—
SD3-EB127-0000	97312362	—	X	—	—	X	—	—	—	—	—	—
SD3-EB128-0000	97312363	—	X	—	—	X	—	—	—	—	—	—
SD3-EB129-0000	97312364	—	X	—	—	X	—	—	—	—	—	—
SD3-EB130-0000	97312365	—	X	—	—	X	—	—	—	—	—	—
SD3-EB131-0000	97312366	—	X	—	—	X	—	—	—	—	—	—
SD3-EB132-0000	97312367	—	X	—	—	X	—	—	—	—	—	—
SD3-EB133-0000	97312368	—	X	—	—	X	—	—	—	—	—	—
SD3-EB134-0000	97312369	—	A	—	—	A	—	—	—	—	—	—
SD3-EB135-0000	97312370	—	X	—	—	X	—	—	—	—	—	—
SD3-EB136-0000	97312371	—	X	—	—	X	—	—	—	—	—	—
SD3-EB137-0000	97312372	—	X	—	—	X	—	—	—	—	—	—
SD3-EB138-0000	97312373	—	A	—	—	A	—	—	—	—	—	—

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 1—Summary of Surface Sediment Chemical and Biological Analyses

Sample Number		Field Analysis ^a	Physical and Chemical Analysis ^b							Biological Analysis ^c		
Weston ID	EPA ID	Immunoassay	TOC	Grain Size	% Moisture	PAHs ^d	PCBs ^e	PCDD/PCDF	Metals ^f	Bioassays ^g	Bioaccum	Benthos
SD3-EB139-0000	97312374	--	A	--	--	A	--	--	--	--	--	--
SD3-EB140-0000	97312375	--	A	--	--	A	--	--	--	--	--	--
SD3-EB141-0000	97312376	--	A	--	--	A	--	--	--	--	--	--
SD3-EB142-0000	97312377	--	A	--	--	A	--	--	--	--	--	--
SD3-EB143-0000	97312378	--	A	--	--	A	--	--	--	--	--	--
SD3-EB144-0000	97312379	--	X	--	--	X	--	--	--	--	--	--
SD3-EB145-0000	97312380	--	A	--	--	A	--	--	--	--	--	--
Background Areas												
SD1-BK01-0000	96162644	--	X	X	X	X	X	X	X	--	--	--
SD1-BK01D-0000	96162645	--	X	X	X	X	X	X	X	--	--	--
SD1-BK02-0000	96162646	--	X	X	X	X	X	X	X	--	--	--
SD1-BK03-0000	96162647	--	X	X	X	X	X	X	X	--	--	--
SD2-BK01-0000	96382545	--	X	X	--	X	X	X	X ^h	X	X	X
SD2-BK04-0000	96382546	--	X	X	--	X	X	X	X ^h	X	X	X
SD2-CARR-0000	--	--	--	X ⁱ	--	--	--	--	--	X	--	--

^aRapid immunoassay methods for carcinogenic PAHs were specified in the Draft Phase 2 SAP Addendum (WESTON, 1996c); sediment collected at each of the immunoassay stations was also archived for potential future laboratory analyses.

^bAnalytical methods were specified in Section 6 of the Phase 1 SAP (WESTON, 1996b).

^cBiological testing methods were specified in the Phase 2 SAP Addendum (WESTON, 1996c, 1996d).

^dAll Phase 1 samples (indicated by WESTON Sample ID prefix "SD1") also analyzed for phenolic compounds and dibenzofuran.

^eAroclors only.

^fMetals analyses were limited to aluminum, arsenic, cadmium, copper, iron, lead, mercury, nickel, and zinc.

^gAmphipod (*Ampelisca abdita*) and echinoderm (*Dendraster excentricus*) acute toxicity tests.

^hMercury only.

ⁱGrain size data consist only of a field screening measurement (of 49% fines).

X: Analyzed.

--: Not analyzed.

A: Sample archived and not analyzed for the RI.

NA: Apparent gross contamination; sample not analyzed for the RI based on assumption that PAH contamination would drive cleanup.

Metal, PAH, and PCB analyses performed by EPA Manchester Lab.

PCDD/PCDF analyses performed by Maxim Technologies, Inc.

TOC analyses performed by ARI, Inc.

Grain Size analyses performed by Soil Technology.

Bioassays conducted by Parametrix, Inc.

Benthic enumeration and taxonomic identification performed by Marine Taxonomic Services.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 2—Summary of Shallow Subsurface Sediment
Compositing Scheme and Chemical Analyses

Station	Depth Interval (ft bgs)		WESTON Sample Number	EPA Sample Number	Analysis ^a								
	Proposed	Actual			PAHs	Phenols	Dibenzofuran	Metals	PCBs	TOC	Grain Size	DRET	MET
EB03	0 - 4	0 - 4	SD2-EB03-0000A	96392707	X	-	-	-	-	X	-	-	-
	0 - 4	0 - 4	SD2-EB03-1000A	96392708	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB03-0040	96392709	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB03-1040	96392710	X	-	-	-	-	X	-	-	-
	8 - 12	8 - 12	SD2-EB03-0080	96392711	X	-	-	-	-	X	-	-	-
	8 - 12	8 - 12	SD2-EB03-1080	96392712	X	-	-	-	-	X	-	-	-
	12 - 16	12 - 16	SD2-EB03-0120	96392719	X	-	-	-	-	X	-	-	-
	12 - 16	12 - 16	SD2-EB03-1120	96392720	X	-	-	-	-	X	-	-	-
EB12	16 - 20	16 - 20	SD2-EB03-0160	96392721	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB03-1160	96392722	X	-	-	-	-	X	-	-	-
	0 - 4	0 - 4	SD2-EB12-0000A	96404900	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB12-0040	96404901	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB12-0080	96404902	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
	16 - 20	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
	16 - 20	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
EB13	0 - 4	0 - 4	SD2-EB13-0000A	96404905	X	X	X	X	X	X	X	-	-
	4 - 8	4 - 8	SD2-EB13-0040	96404906	X	X	X	X	X	X	X	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB13-0080	96404907	X	X	X	X	X	X	X	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB13-0120	96404908	X	X	X	X	X	X	X	-	-
	16 - 20	16 - 20	SD2-EB13-0160	96404909	X	X	X	X	X	X	X	-	-
EB15	0 - 4	0 - 4	SD2-EB15-0000A	96392723	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB15-0040	96392724	X	-	-	-	-	X	-	[X (G1)]	[X (G1)]
	8 - 12	8 - 12	SD2-EB15-0080	96392725	X	-	-	-	-	X	-	[X (G1)]	[X (G1)]
	12 - 16	12 - 16	SD2-EB15-0120	96392726	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB15-0160	96392727	X	-	-	-	-	X	-	-	-
EB27	0 - 4	0 - 4	SD2-EB27-0000A	96392734	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB27-0040	96392735	X	-	-	-	-	X	-	[X (G1)]	[X (G1)]
	8 - 12	8 - 12	SD2-EB27-0080	96392736	X	-	-	-	-	X	-	[X (G1)]	[X (G1)]
	12 - 16	12 - 16	SD2-EB27-0120	96392737	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB27-0160	96392738	X	-	-	-	-	X	-	-	-
EB31	0 - 4	0 - 4	SD2-EB31-0000A	96404910	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB31-0040	96404911	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB31-0080	96404912	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB31-0120	96404913	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB31-0160	96404914	A	-	-	-	-	A	-	-	-
EB32	0 - 4	0 - 4	SD2-EB32-0000A	96404915	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB32-0040	96404916	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB32-0080	96404917	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB32-0120	96404918	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB32-0160	96404919	X	-	-	-	-	X	-	-	-
EB34	0 - 4	0 - 4	SD2-EB34-0000A	96404920	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB34-0040	96404921	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB34-0080	96404922	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB34-0120	96404923	A	-	-	-	-	A	-	-	-
	16 - 20	16 - 20	SD2-EB34-0160	96404924	A	-	-	-	-	A	-	-	-
EB41	0 - 4	0 - 4	SD2-EB41-0000A	96404925	X	X	X	X	X	X	X	-	-
	4 - 8	4 - 8	SD2-EB41-0040	96404926	X	X	X	X	X	X	X	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB41-0080	96404927	X	X	X	X	X	X	X	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB41-0120	96404928	X	X	X	X	X	X	X	-	-
	16 - 20	16 - 20	SD2-EB41-0160	96404929	X	X	X	X	X	X	X	-	-

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 2—Summary of Shallow Subsurface Sediment
Compositing Scheme and Chemical Analyses

Station	Depth Interval (ft bgs)		WESTON Sample Number	EPA Sample Number	Analysis ^a								
	Proposed	Actual			PAHs	Phenols	Dibenzofuran	Metals	PCBs	TOC	Grain Size	DRET	MET
EB42	0 - 4	0 - 4	SD2-EB42-0000A	96404930	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB42-0040	96404931	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
	12 - 16	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
	16 - 20	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
EB49	0 - 4	0 - 4	SD2-EB49-0000A	96392728	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB49-0040	96392729	X	-	-	-	-	X	-	[X (G1)]	[X (G1)]
	8 - 12	8 - 12	SD2-EB49-0080	96392731	X	-	-	-	-	X	-	[X (G1)]	[X (G1)]
	12 - 16	12 - 16	SD2-EB49-0120	96392732	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB49-0160	96392733	X	-	-	-	-	X	-	-	-
EB66	0 - 4	0 - 4	SD2-EB66-0000A	96404935	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB66-0040	96404936	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB66-0080	96404937	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB66-0120	96404938	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB66-0160	96404939	X	-	-	-	-	X	-	-	-
EB72	0 - 4	0 - 4	SD2-EB72-0000A	96404940	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB72-0040	96404941	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB72-0080	96404942	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB72-0120	96404943	A	-	-	-	-	A	-	-	-
	16 - 20	16 - 18.7	SD2-EB72-0160	96404944	A	-	-	-	-	A	-	-	-
EB78	0 - 4	0 - 4	SD2-EB78-0000A	96404945	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB78-0040	96404946	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB78-0080	96404947	A	-	-	-	-	A	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB78-0120	96404948	A	-	-	-	-	A	-	-	-
	16 - 20	16 - 20	SD2-EB78-0160	96404949	A	-	-	-	-	A	-	-	-
EB87	0 - 4	0 - 4	SD2-EB87-0000A	96404950	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB87-0040	96404951	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB87-0080	96404952	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB87-0120	96404953	X	-	-	-	-	X	-	-	-
	16 - 20	16 - 20	SD2-EB87-0160	96404954	A	-	-	-	-	A	-	-	-
EB104	0 - 4	0 - 4	SD2-EB104-0000A	96404955	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 8	SD2-EB104-0040	96404956	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	8 - 12	SD2-EB104-0080	96404957	A	-	-	-	-	A	-	[X (G2)]	[X (G2)]
	12 - 16	12 - 16	SD2-EB104-0120	96404958	A	-	-	-	-	A	-	-	-
	16 - 20	16 - 20	SD2-EB104-0160	96404959	A	-	-	-	-	A	-	-	-
EB113	0 - 4	0 - 4	SD2-EB113-0000A	96404960	X	-	-	-	-	X	-	-	-
	4 - 8	4 - 7	SD2-EB113-0040	96404961	X	-	-	-	-	X	-	[X (G2)]	[X (G2)]
	8 - 12	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
	12 - 16	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
	16 - 20	NR	NR	NR	NR	-	-	-	-	NR	-	-	-
Group 1	4 - 8	4 - 8	SD2-EBC01-0040	96392739	-	-	-	-	-	-	-	X	X
	8 - 12	8 - 12	SD2-EBC01-0080	96404965	-	-	-	-	-	-	-	X	X
Group 2	4 - 8	4 - 8	SD2-EBC02-0040	96404966	-	-	-	-	-	-	-	X	X
	8 - 12	8 - 12	SD2-EBC02-0080	96404967	-	-	-	-	-	-	-	X	X

^aAnalytical methods were specified in the Phase 1 SAP (WESTON, 1996b) and Draft Phase 2 SAP Addendum (WESTON, 1996c).

^bMetal analyses limited to arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

X: Analyzed.

A: Sample archived and not analyzed for the RI.

NR: No recovery or refusal encountered; no analysis possible.

-: Not analyzed

G1: Compositing as part of Group 1 (EBC01), which included Stations EB15, EB27, and EB49.

G2: Compositing as part of Group 2 (EBC02), which included Stations EB12, EB13, EB31, EB32, EB34, EB41, EB42, EB66, EB72, EB78, EB87, EB104, and EB113.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 3—Summary of Deep Subsurface Sediment Field and Laboratory Analyses

Station	Depth Interval (ft bgs)	WESTON Sample Number	EPA Sample Number	Field Analysis ^a		Laboratory Analysis ^b			
				UV	Immuno- assay	Eng. Param. ^c	PAHs	TOC	Grain Size
EB14	0 - 3	SDEB14-0000	--	--	--	X	--	--	--
	3 - 6	SDEB14-0030	--	--	--	X	--	--	--
	8 - 10	SD2-EB14-0080	--	--	--	--	--	A	A
	12 - 14	SD2-EB14-0120	--	--	--	--	--	A	A
	20 - 22	SD2-EB14-0200	--	X	--	--	A	--	--
	22 - 24	SD2-EB14-0220	--	--	--	--	A	--	--
	24 - 26	SD2-EB14-0240	--	X	--	--	A	--	--
	26 - 28	SD2-EB14-0260	--	--	--	--	A	A	A
	28 - 30	SD2-EB14-0280	--	X	--	--	A	--	--
	30 - 32	SD2-EB14-0300	--	--	X	--	A	--	--
	32 - 34	SD2-EB14-0320	96464640	X	--	--	A	X	X
	42 - 44	SD2-EB14-0420	--	--	--	--	--	A	A
	60 - 62	SD2-EB14-0600	--	X	--	--	A	--	--
	62 - 64	SD2-EB14-0620	--	--	--	--	A	--	--
	64 - 66	SD2-EB14-0640	--	X	X	--	A	--	--
	66 - 68	SD2-EB14-0660	--	--	X	--	--	A	A
	68 - 70	SD2-EB14-0680	--	X	X	--	A	--	--
	70 - 72	SD2-EB14-0700	96464641	--	X	--	A	X	X
	72 - 74	SD2-EB14-0720	--	X	X	--	A	--	--
	74 - 76	SD2-EB14-0740	--	--	X	--	--	A	A
	76 - 78	SD2-EB14-0760	--	X	--	--	A	--	--
	78 - 80	SD2-EB14-0780	--	--	--	--	A	--	--
	80 - 82	SD2-EB14-0800	--	X	--	--	A	--	--
	82 - 84	SD2-EB14-0820	--	--	--	--	A	--	--
	84 - 85	SD2-EB14-0840	--	--	--	--	A	--	--
EB16	0 - 3	SDEB16-0000	--	--	--	X	--	--	--
	3 - 6	SDEB16-0030	--	--	--	X	--	--	--
	12 - 14	SD2-EB16-0120	--	--	--	--	A	A	A
	20 - 22	SD2-EB16-0200	--	X	--	--	A	--	--
	22 - 24	SD2-EB16-0220	--	X	--	--	A	--	--
	24 - 26	SD2-EB16-0240	--	--	--	--	A	--	--
	26 - 28	SD2-EB16-0260	--	X	--	--	A	--	--
	28 - 30	SD2-EB16-0280	--	--	--	--	A	A	A
	30 - 32	SD2-EB16-0300	--	X	--	--	--	--	--
	32 - 34	SD2-EB16-0320	96464647	--	X	--	--	X	X
	52 - 54	SD2-EB16-0520	--	--	--	--	--	A	A
	60 - 62	SD2-EB16-0600	--	X	X	--	A	--	--
	62 - 64	SD2-EB16-0620	--	--	X	--	A	A	A
	64 - 66	SD2-EB16-0640	--	X	X	--	A	--	--
	66 - 68	SD2-EB16-0660	--	--	X	--	A	--	--
	68 - 70	SD2-EB16-0680	--	X	X	--	A	--	--
	70 - 72	SD2-EB16-0700	--	--	X	--	A	--	--
	72 - 74	SD2-EB16-0720	96464648	X	X	--	A	X	X
	74 - 76	SD2-EB16-0740	--	--	X	--	A	--	--
	76 - 78	SD2-EB16-0760	--	X	X	--	A	--	--
	78 - 80	SD2-EB16-0780	--	--	X	--	A	--	--
	80 - 82	SD2-EB16-0800	--	--	X	--	A	--	--
	82 - 84	SD2-EB16-0820	--	--	X	--	A	--	--
	84 - 85	SD2-EB16-0840	--	--	X	--	A	--	--

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 3—Summary of Deep Subsurface Sediment Field and Laboratory Analyses

Station	Depth Interval (ft bgs)	WESTON Sample Number	EPA Sample Number	Field Analysis ^a		Laboratory Analysis ^b			
				UV	Immuno- assay	Eng. Param. ^c	PAHs	TOC	Grain Size
EB114	0 - 3	SDEB114-0000	—	—	—	X	—	—	—
	3 - 6	SDEB114-0030	—	—	—	X	—	—	—
	8 - 10	SD2-EB114-0080	—	—	—	—	—	A	A
	12 - 14	SD2-EB114-0120	—	—	—	—	—	A	A
	20 - 22	SD2-EB114-0200	—	X	—	—	A	—	—
	22 - 24	SD2-EB114-0220	—	—	—	—	A	—	—
	24 - 26	SD2-EB114-0240	—	X	—	—	A	—	—
	26 - 28	SD2-EB114-0260	—	—	—	—	A	—	—
	28 - 30	SD2-EB114-0280	—	X	X	—	A	—	—
	30 - 32	SD2-EB114-0300	96464642	X	X	—	A	X	X
	34 - 36	SD2-EB114-0340	—	—	X	—	A	—	—
	38 - 40	SD2-EB114-0380	96464643	—	—	—	—	X	X
	56 - 58	SD2-EB114-0560	96464644	—	—	—	—	X	X
	60 - 62	SD2-EB114-0600	—	X	X	—	A	—	—
	62 - 64	SD2-EB114-0620	—	—	X	—	A	—	—
	64 - 66	SD2-EB114-0640	96464645	X	X	—	A	X	X
	66 - 68	SD2-EB114-0660	—	—	X	—	A	—	—
	68 - 70	SD2-EB114-0680	—	X	—	—	A	—	—
	70 - 72	SD2-EB114-0700	—	—	—	—	A	—	—
	72 - 74	SD2-EB114-0720	—	X	—	—	A	—	—
	74 - 76	SD2-EB114-0740	—	—	—	—	A	—	—
	76 - 78	SD2-EB114-0760	—	X	—	—	A	A	A
	80 - 82	SD2-EB114-0800	—	X	—	—	A	—	—
	82 - 84	SD2-EB114-0820	—	—	—	—	A	—	—
	84 - 86	SD2-EB114-0840	—	X	X	—	A	—	—
	86 - 88	SD2-EB114-0860	—	—	X	—	A	—	—
	88 - 90	SD2-EB114-0880	—	X	X	—	A	—	—
	90 - 92	SD2-EB114-0900	—	—	X	—	A	—	—
	92 - 94	SD2-EB114-0920	96464646	X	X	—	A	X	X
	94 - 96	SD2-EB114-0940	—	—	X	—	A	—	—

^aAnalytical methods were discussed in the revised Phase 2 SAP Addendum (WESTON, 1996d).

^bAnalytical methods were specified in the Phase 1 SAP (WESTON, 1996b).

^cEngineering parameters consisted of Atterburg limits, engineering classification, specific gravity, grain size, percent moisture, triaxial shear (consolidated and unconsolidated), consolidation tests, and unconfined compressive strength.

X: Analyzed.

—: Not analyzed.

A: Archived; not analyzed for the RI.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 4—Summary of Clam and Fish Tissue Chemical Analyses

Sample Number		Media	Chemical Analysis ^a				
Weston ID	EPA ID		Lipid	PAHs	PCBs ^b	Diox/Fur	Mercury
PSR Marine Sediments Unit							
CTI-EB49-0000	96454330	Clam Whole Body ^c	X	X	X	X	X
CTI-EB60-0000	96454332	Clam Whole Body ^c	X	X	X	X	X
CTI-EB67-0000	96454333	Clam Whole Body ^c	X	X	X	X	X
CTI-EB77-0000	96454334	Clam Whole Body ^c	X	X	X	X	X
CTI-EB80-0000	96454335	Clam Whole Body ^c	X	X	X	X	X
CTI-EB85-0000	96454336	Clam Whole Body ^c	X	X	X	X	X
CTI-EB87-0000	96454337	Clam Whole Body ^c	X	X	X	X	X
CTI-EB104-0000	96454338	Clam Whole Body ^c	X	X	X	X	X
CTI-EB106-0000	96454339	Clam Whole Body ^c	X	X	X	X	X
FT2-WEST-ES-WB-R2	96382503	Fish Whole Body ^d	X	—	X	X	X
FT2-WEST-ES-WB-R4	96382504	Fish Whole Body ^d	X	—	X	X	X
FT2-WEST-ES-WB-R5	96382505	Fish Whole Body ^d	X	—	X	X	X
FT2-NORTH-ES-WB-R1	96382509	Fish Whole Body ^d	X	—	X	X	X
FT2-NORTH-ES-WB-R2	96382510	Fish Whole Body ^d	X	—	X	X	X
FT2-NORTH-ES-WB-R3	96382511	Fish Whole Body ^d	X	—	X	X	X
FT2-WEST-ES-FT-R1	96382500	Fish Fillet ^d	X	—	X	X	X
FT2-WEST-ES-FT-R3	96382501	Fish Fillet ^d	X	—	X	X	X
FT2-WEST-ES-FT-R4	96382502	Fish Fillet ^d	X	—	X	X	X
FT2-NORTH-ES-FT-R1	96382506	Fish Fillet ^d	X	—	X	X	X
FT2-NORTH-ES-FT-R2	96382507	Fish Fillet ^d	X	—	X	X	X
FT2-NORTH-ES-FT-R3	96382508	Fish Fillet ^d	X	—	X	X	X
Background Areas							
CTI-BK01-0000	96454340	Clam Whole Body ^c	X	X	X	X	X
CTI-BK04-0000	96454341	Clam Whole Body ^c	X	X	X	X	X
FT2-ALKI-ES-WB-R1	96382521	Fish Whole Body ^d	X	—	X	X	X
FT2-ALKI-ES-WB-R2	96382522	Fish Whole Body ^d	X	—	X	X	X
FT2-ALKI-ES-WB-R3	96382523	Fish Whole Body ^d	X	—	X	X	X
FT2-MAGL-ES-WB-R1	96382515	Fish Whole Body ^d	X	—	X	X	X
FT2-MAGL-ES-WB-R2	96382516	Fish Whole Body ^d	X	—	X	X	X
FT2-MAGL-ES-WB-R3	96382517	Fish Whole Body ^d	X	—	X	X	X
FT2-ALKI-ES-FT-R1	96382518	Fish Fillet ^d	X	—	X	X	X
FT2-ALKI-ES-FT-R2	96382519	Fish Fillet ^d	X	—	X	X	X
FT2-ALKI-ES-FT-R3	96382520	Fish Fillet ^d	X	—	X	X	X
FT2-MAGL-ES-FT-R1	96382512	Fish Fillet ^d	X	—	X	X	X
FT2-MAGL-ES-FT-R2	96382513	Fish Fillet ^d	X	—	X	X	X
FT2-MAGL-ES-FT-R3	96382514	Fish Fillet ^d	X	—	X	X	X

^aAnalytical methods were specified in the Phase 1 SAP (WESTON, 1996b) and Draft Phase 2 SAP Addendum (WESTON, 1996c).

^bAroclors only.

^c*Macoma nasuta* exposed in laboratory to site-collected sediment.

^dEnglish sole collected from the site.

X: Analyzed.

—: Not analyzed.

Lipid, PAH, PCB, and Mercury analyses performed by EPA Manchester Lab.

Dioxin/Furan analyses performed by Maxim Technologies, Inc.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 5—SMS and AET Chemical Screening Criteria for Sediment COCs

Chemical	Sediment Management Standards ^a		Apparent Effects Threshold ^k	
	SQS ^b	CSL/MCUL ^c	LAET ⁱ	2LAET ^j
Organics (ug/kg)				
Acenaphthylene	66,000 ^e	66,000 ^e	1,300 ^h	1,300 ^h
Acenaphthene	16,000 ^e	57,000 ^e	500 ^h	730 ^h
Anthracene	220,000 ^e	1,200,000 ^e	960 ^h	4,400 ^h
Benz(a)anthracene	110,000 ^e	270,000 ^e	1,300 ^h	1,600 ^h
Benzo(a)pyrene	99,000 ^e	210,000 ^e	1,600 ^h	3,000 ^h
Total Benzofluoranthenes ^g	230,000 ^e	450,000 ^e	3,200 ^h	3,600 ^h
Benzo(g,h,i)perylene	31,000 ^e	78,000 ^e	670 ^h	720 ^h
Chrysene	110,000 ^e	460,000 ^e	1,400 ^h	2,800 ^h
Dibenz(a,h)anthracene	12,000 ^e	33,000 ^e	230 ^h	540 ^h
Dibenzofuran	15,000 ^e	58,000 ^e	540 ^h	700 ^h
2,4-Dimethylphenol	29 ^h	29 ^h	29 ^h	72 ^h
Fluoranthene	160,000 ^e	1,200,000 ^e	1,700 ^h	2,500 ^h
Fluorene	23,000 ^e	79,000 ^e	540 ^h	1,000 ^h
Total HPAH	960,000 ^{e,f}	5,300,000 ^{e,f}	12,000 ^h	17,000 ^h
Indeno(1,2,3-cd)pyrene	34,000 ^e	88,000 ^e	600 ^h	690 ^h
Total LPAH	370,000 ^{d,e}	780,000 ^{d,e}	5200 ^h	13,000 ^h
2-Methylnaphthalene	38,000 ^e	64,000 ^e	670 ^h	1,400 ^h
2-Methylphenol	63 ^h	63 ^h	63 ^h	72 ^h
4-Methylphenol	670 ^h	670 ^h	670 ^h	1,800 ^h
Naphthalene	99,000 ^e	170,000 ^e	2,100 ^h	2,400 ^h
Total PCBs ^l	12,000 ^e	65,000 ^e	130 ^h	1,000 ^h
Pentachlorophenol	360 ^h	690 ^h	360 ^h	690 ^h
Phenanthrene	100,000 ^e	480,000 ^e	1,500 ^h	5,400 ^h
Phenol	420 ^h	1,200 ^h	420 ^h	1,200 ^h
Pyrene	1,000,000 ^e	1,400,000 ^e	2,600 ^h	3,300 ^h
Inorganics (mg/kg)				
Arsenic	57 ^h	93 ^h	57 ^h	93 ^h
Cadmium	5.1 ^h	6.7 ^h	5.1 ^h	6.7 ^h
Chromium (total)	260 ^h	270 ^h	260 ^h	270 ^h
Copper	390 ^h	390 ^h	390 ^h	530 ^h

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 5—SMS and AET Chemical Screening Criteria for Sediment COCs

Chemical	Sediment Management Standards ^a		Apparent Effects Threshold ^k	
	SQS ^b	CSL/MCUL ^c	LAET ⁱ	2LAET ^j
Lead	450 ^h	530 ^h	450 ^h	530 ^h
Mercury	0.41 ^h	0.59 ^h	0.41 ^h	0.59 ^h
Zinc	410 ^h	960 ^h	410 ^h	960 ^h

^aChapter 173-204 WAC.

^bSediment Quality Standards.

^cCleanup Screening Levels and Minimum Cleanup Levels.

^dThis value represents the sum of the following compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene; the LPAH criterion does not represent the sum of the criteria values for the individual compounds.

^eNormalized to total organic carbon content.

^fThis value represents the sum of the following compounds: fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3 cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene; the HPAH criterion does not represent the sum of the criteria values for the individual compounds.

^gSum of the concentrations of the "b," "j," and "k" isomers.

^hDry-weight basis.

ⁱLowest Apparent Effects Threshold.

^jSecond-lowest Apparent Effects Threshold.

^kBarrick et al., 1988.

^lThis value represents the sum of detected Aroclors.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 6—Surface Sediment Background Concentrations for Selected Contaminants^a

Compound	Concentration						
	Phase 1				Phase 2		Average
	BK01	BK01D ^b	BK02	BK03	BK01	BK04	
2,3,7,8-TCDD Equiv. (ng/kg DW)	0.619	0.518	4.029	0.184	0.290	0.670	1.052
2,3,7,8-TCDD Equiv. (ng/kg TOCN)	82.5	55.1	366.3	NA	12.100	95.700	122.340
Total LPAHs (ug/kg DW)	3,463	1,008	286	36	847	644	1,044
Total LPAHs (ug/kg TOCN)	461,733	107,191	25,991	--	35,292	91,957	144,433
Total HPAHs (ug/kg DW)	14,969	3,173	1,528	38	3,608	1,331	4,104
Total HPAHs (ug/kg TOCN)	1,995,867	337,511	138,891	--	150,312	190,114	562,539
Total PAHs (ug/kg DW)	15,007	3,485	1,252	38	3,554	1,714	1,052
Total PCBs (ug/kg DW)	5.8	10.7	50.0	2.3	23 U	199.0	46
Total PCBs (ug/kg TOCN)	773	1,138	4,545	--	23 U	28,429	6,979

See Figure 7 for background locations.

^aMethods used for deriving and summing 2,3,7,8-TCDD equivalents are described in RI Appendix F (WESTON 1998).

^bField replicate at Station BK01.

DW: Dry-weight.

TOCN: Normalized to total organic carbon (TOC) content.

NA: Normalization not appropriate; TOC content less than 0.5 percent.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 7—Summary Statistics for Surface Sediment COCs

Constituent	# of Stations Analyzed	# of Detected Values	Frequency of Detection (%)	Detected Concentrations						# of Stations Exceeding Screening Criteria		Frequency of Exceedance of Screening Criteria (%) ^b		Average CSL/2LAET/ER ^a
				Dry-Weight			TOC-Normalized							
				Minimum	Maximum	Location of Maximum	Minimum	Maximum	Location of Maximum	SQS/LAET ^c	CSL/2LAET ^c	SQS/LAET	CSL/2LAET	
PAHs (µg/kg)														
Naphthalene	106	104	98	38	85,700	EB09	3,324	2,818,182	EB05	59	38	56	36	3.55
Acenaphthylene	106	106	100	10	8,380	EB13	676	82,174	EB27	4	4	4	4	1.18
Acenaphthene	106	105	99	20	397,000	EB13	1,448	766,234	EB05	83	46	78	43	3.81
Fluorene	106	106	100	21	218,000	EB13	2,133	760,000	EB19	74	36	70	34	3.04
Phenanthrene	106	106	100	96	549,000	EB13	9,857	3,468,750	EB02	64	17	60	16	2.49
Anthracene	106	106	100	42	1,750,000	EB13	4,552	1,900,000	EB02	17	5	16	5	1.39
Total LPAH	106	106	100	248	2,948,080	EB13	21,990	6,988,052	EB05	59	36	56	34	2.74
Fluoranthene	106	106	100	164	2,060,000	EB13	19,095	8,695,652	EB27	57	13	54	12	2.99
Pyrene	106	106	100	187	1,140,000	EB13	16,048	6,956,522	EB27	17	14	16	13	2.59
Benzo(a)anthracene	106	106	100	61	382,000	EB13	11,714	1,891,304	EB27	26	12	25	11	2.56
Chrysene	106	106	100	100	526,000	EB13	16,238	1,860,870	EB27	44	10	42	9	2.24
Total Benzofluoranthenes	106	106	100	177	302,900	EB13	27,333	1,743,478	EB27	32	16	30	15	1.56
Benzo(a)pyrene	106	106	100	84	114,000	EB13	12,857	726,087	EB27	29	11	27	10	1.62
Indeno(1,2,3-cd)pyrene	106	106	100	45	34,400	EB13	6,190	215,652	EB27	41	9	39	8	1.50
Dibenz(a,h)anthracene	106	99	93	4.2	10,700	EB13	1,029	79,130	EB27	30	7	28	7	1.49
Benzo(g,h,i)perylene	106	106	100	46	26,600	EB13	5,238	177,826	EB27	41	7	39	7	1.61
Total HPAH	106	106	100	869	4,596,600	EB13	117,257	22,346,522	EB27	48	11	45	10	2.03
2-Methylnaphthalene	106	105	99	16	26,000	EB13	1,119	646,753	EB05	42	31	40	29	2.26
OTHER SVOCs (µg/kg)														
2,4-Dimethylphenol	44	26	59	21	1,310	EB09	--	--	--	23	23	52	52	
2-Methylphenol	44	31	70	7.2	601	EB09	--	--	--	6	6	14	14	
4-Methylphenol	44	43	98	17	6,770	EB02	--	--	--	4	4	9	9	
Pentachlorophenol	44	8	18	158	380	EB24	--	--	--	1	0	2	0	
Phenol	44	30	68	22	3,980	EB02	--	--	--	3	1	7	2	
Dibenzofuran	67	67	100	40	62,800	EB13	1,895	800,000	EB19	54	29	81	43	3.53
2-Chloronaphthalene	51	0	0	<3.5	<149	--	--	--	--	--	--	--	--	--
Carbazole	51	46	90	13	3,090	EB87	--	--	--	--	--	--	--	--
1-Methylnaphthalene	28	28	100	31	4,570	EB87	--	--	--	--	--	--	--	--
Retene	28	28	100	115	635	EB87	--	--	--	--	--	--	--	--
PCBs (µg/kg)														
Total PCBs	42	42	100	24	1,340	EB06	3,923	78,182	EB08	25	2	60	5	1.14
DIOXINS/FURANS (ng/kg)														
2,3,7,8-TCDD (Equiv.)	38	38	100	1.97	156	EB26	102	11,819	EB05	--	--	--	--	--

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 7—Summary Statistics for Surface Sediment COCs

Constituent	# of Stations Analyzed	# of Detected Values	Frequency of Detection (%)	Detected Concentrations						# of Stations Exceeding Screening Criteria		Frequency of Exceedance of Screening Criteria (%) ^b		Average CSL/2LAET ER ^a
				Dry-Weight			TOC-Normalized							
				Minimum	Maximum	Location of Maximum	Minimum	Maximum	Location of Maximum	SQS/LAET ^c	CSL/2LAET ^c	SQS/LAET	CSL/2LAET	
INORGANICS (mg/kg)														
Arsenic	44	39	89	4.7	24	EB13	--	--	--	0	0	0	0	--
Cadmium	44	37	84	0.38	2.7	EB08	--	--	--	0	0	0	0	--
Chromium	44	44	100	9.2	251	EB09	--	--	--	0	0	0	0	--
Copper	44	44	100	12	410	EB01	--	--	--	1	1	2	2	1.05
Lead	44	44	100	6.7	192	EB09	--	--	--	0	0	0	0	--
Mercury	53	53	100	0.02	4.2	EB12	--	--	--	19	11	36	21	1.98
Zinc	44	44	100	35	639	EB27	--	--	--	3	0	7	0	--

^aAverage ERs calculated using only those individual ERs >1.0 and excluding stations EB09 and EB13; these two stations were consistently characterized by chemical concentrations orders of magnitude above 2LAET screening values, which substantially skewed the average values and effectively masked any apparent differences or trends in contaminant distribution.

^bFrequencies based on total number of stations analyzed.

^cThe nonionic/nonpolar organic chemical data for the following stations were compared with AETs based on TOC content outside the range determined to be appropriate for normalization: EB04, EB09, EB13, EB28, EB34, EB37, EB94.

--: Not applicable.

<: Not detected at dry-weight detection limit shown.

ER = Exceedance Ratio. ERs are calculated by dividing the sample concentration for a given analyte by its screening criterion.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 8—Summary Statistics for Shallow Subsurface (0 to 20 feet bgs) Sediment COCs

Constituent	# of Core Intervals Analyzed	# of Detected Values	Frequency of Detection (%)	Detected Concentrations						# of Core Intervals Exceeding Screening Criteria		Frequency of Exceedance of Screening Criteria (%) ^b		Average CSU/2LAET ER ^a
				Dry-Weight			TOC-Normalized							
				Minimum	Maximum	Location of Maximum	Minimum	Maximum	Location of Maximum					
PAHs (ug/kg)														
Naphthalene	65	56	86	4.0	3,310,000	EB13-0000A	588	91,142,857	EB27-0080	29	28	45	40	98.23
Acenaphthylene	65	39	60	1.4	33,800	EB27-0080	240	965,714	EB27-0080	9	9	14	14	4.20
Acenaphthene	65	54	83	2.1	1,490,000	EB27-0080	339	42,571,429	EB27-0080	36	30	55	46	131.79
Fluorene	65	51	78	5.0	1,490,000	EB27-0080	806	42,571,429	EB27-0080	34	29	52	45	80.15
Phenanthrene	65	60	92	4.2	3,750,000	EB27-0080	1,069	107,142,857	EB27-0080	32	21	49	32	61.89
Anthracene	65	61	94	1.2	1,950,000	EB13-0000A	271	11,600,000	EB27-0080	18	11	28	17	59.05
Total LPAH	65	63	97	1.2	10,359,800	EB27-0080	291	295,994,286	EB27-0080	32	25	49	38	73.11
Fluoranthene	65	57	88	7.8	1,530,000	EB27-0080	1,300	43,714,286	EB27-0080	28	18	43	28	56.49
Pyrene	65	62	95	4.0	933,000	EB27-0080	909	26,657,143	EB27-0080	19	16	29	25	27.95
Benzo(a)anthracene	65	45	69	4.7	221,000	EB27-0080	1,784	6,314,286	EB27-0080	20	16	31	25	16.04
Chrysene	65	49	75	2.6	201,000	EB27-0080	371	5,742,857	EB27-0080	21	14	32	22	10.69
Total Benzofluoranthenes	65	51	78	3.6	147,900	EB27-0080	1,055	4,225,714	EB27-0080	19	14	29	22	5.32
Benzo(a)pyrene	65	40	62	6.1	61,700	EB27-0080	813	1,762,857	EB27-0080	20	13	31	20	3.36
Indeno(1,2,3-cd)pyrene	65	43	66	2.7	17,700	EB27-0080	397	505,714	EB27-0080	20	7	31	11	5.38
Dibenz(a,h)anthracene	65	34	52	1.7	6,210	EB27-0080	304	177,429	EB27-0080	18	8	28	12	3.22
Benzo(g,h,i)perylene	65	42	65	2.9	14,400	EB27-0080	426	411,429	EB27-0080	20	8	31	12	3.70
Total HPAH	65	62	95	4.0	3,132,910	EB27-0080	909	89,511,714	EB27-0080	26	15	40	23	20.60
2-Methylnaphthalene	65	61	94	1.2	1,570,000	EB27-0080	200	44,857,143	EB27-0080	28	25	43	38	75.81
OTHER SVOCs (ug/kg)														
2,4-Dimethylphenol	10	2	20	316	3,680	EB13-0000A	--	--	--	2	2	20	20	68.89
2-Methylphenol	10	0	0	<9.1	<335	--	--	--	--	0	0	0	0	--
4-Methylphenol	10	3	30	107	2,060	EB13-0000A	--	--	--	1	1	10	10	3.07
Pentachlorophenol	10	0	0	<18	<670	--	--	--	--	0	0	0	0	--
Phenol	10	0	0	<9.1	<335	--	--	--	--	0	0	0	0	--
Dibenzofuran	10	8	80	27	612,000	EB13-0000A	15,778	3,013,158	EB13-0080	6	5	60	50	198.13
2-Chloronaphthalene	49	1	2	10,600	10,600	EB72-0000A	--	--	--	--	--	--	--	--
Carbazole	49	30	61	0.003	95,400	EB27-0080	--	--	--	--	--	--	--	--
1-Methylnaphthalene	59	57	97	1.2	897,000	EB27-0080	--	--	--	--	--	--	--	--
Retene	49	49	100	12	83,300	EB113-0040	--	--	--	--	--	--	--	--
PCBs (ug/kg)														
Total PCBs	10	1	10	291	291	EB13-0000A	--	--	--	1	0	10	0	--

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 8—Summary Statistics for Shallow Subsurface (0 to 20 feet bgs) Sediment COCs

Constituent	# of Core Intervals Analyzed	# of Detected Values	Frequency of Detection (%)	Detected Concentrations						# of Core Intervals Exceeding Screening Criteria		Frequency of Exceedance of Screening Criteria (%) ^b		Average CSL/2LAET ER ^a
				Dry-Weight			TOC-Normalized							
				Minimum	Maximum	Location of Maximum	Minimum	Maximum	Location of Maximum	SQS/LAET ^c	CSL/2LAET ^c	SQS/LAET	CSL/2LAET	
INORGANICS (mg/kg)														
Arsenic	10	7	70	4.5	11.0	EB13-0000A	--	--	--	0	0	0	0	--
Cadmium	10	2	20	0.34	1.6	EB13-0000A	--	--	--	0	0	0	0	--
Chromium	10	10	100	10	67	EB13-0000A	--	--	--	0	0	0	0	--
Copper	10	10	100	7.6	62	EB13-0000A	--	--	--	0	0	0	0	--
Lead	10	10	100	3.0	102.0	EB41-0000A	--	--	--	0	0	0	0	--
Mercury	10	9	90	0.023	0.71	EB13-0000A	--	--	--	1	1	10	10	1.20
Nickel	10	10	100	8.8	26	EB13-0000A	--	--	--	0	0	0	0	--
Zinc	10	10	100	20	252	EB13-0000A	--	--	--	0	0	0	0	--

^aAverage ERs calculated using only those individual ERs >1.0.

^bFrequencies based on total number of stations analyzed.

^cThe nonionic/nonpolar organic chemical data for several core intervals were compared with AETs based on TOC content outside the range determined to be appropriate for normalization.

--: Not applicable: Constituent not detected, screening criteria based on dry-weight data or not available, or TOC content outside range for normalization.

<: Not detected at dry-weight detection limit shown.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 9—Summary of Human Health Chemicals of Concern and Fish Tissue Exposure Point Concentrations

Scenario Timeframe: Current (Baseline)

Medium: Fish Tissue

Exposure Medium: Fish Fillet Tissue

Exposure Point	Chemical of Concern	Concentration Detected ^a		Units	Frequency of Detection	Exposure Point Concentration ^b	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum					
Ingestion of Fish Fillets	Aroclor 1242	13	52	ug/kg-WW	3/6	553	ug/kg-WW	90th Percentile
	Aroclor 1254	54	330	ug/kg-WW	6/6	672	ug/kg-WW	90th Percentile
	Aroclor 1260	51	140	ug/kg-WW	6/6	297	ug/kg-WW	90th Percentile
	Total PCB	105	492	ug/kg-WW	6/6	1329	ug/kg-WW	90th Percentile
	Total 2,3,7,8-TCDD (Equiv.)	0.00007	0.00031	ug/kg-WW	2/3	0.0521	ug/kg-WW	90th Percentile

^aBased on 6 composite fish samples collected from the site.

^bSite-wide exposure concentration estimated from surface sediment concentrations using a biota-sediment accumulation factor.

WW: Wet-weight.

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Table 10—Summary of Human Health Chemicals of Concern and Shellfish Tissue Exposure Point Concentrations

Scenario Timeframe: Current (Baseline)

Medium: Shellfish

Exposure Medium: Clam Whole Body Tissue

Exposure Point	Chemical of Concern	Concentration Detected ^a		Units	Frequency of Detection	Exposure Point Concentration ^b	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum					
Ingestion of Shellfish	Naphthalene	6.7	15	ug/kg-WWW	3/9	760	ug/kg-WWW	90th Percentile
	Acenaphthylene	2.4	4.8	ug/kg-WWW	7/9	54	ug/kg-WWW	90th Percentile
	Acenaphthene	3.6	5.2	ug/kg-WWW	3/9	409	ug/kg-WWW	90th Percentile
	Fluorene	5.3	47	ug/kg-WWW	4/9	332	ug/kg-WWW	90th Percentile
	Phenanthrene	11	100	ug/kg-WWW	9/9	933	ug/kg-WWW	90th Percentile
	Anthracene	15	1520	ug/kg-WWW	9/9	398	ug/kg-WWW	90th Percentile
	Total LPAH	28	1690	ug/kg-WWW	9/9	3075	ug/kg-WWW	90th Percentile
	Fluoranthene	27	911	ug/kg-WWW	9/9	1720	ug/kg-WWW	90th Percentile
	Pyrene	118	1180	ug/kg-WWW	9/9	2674	ug/kg-WWW	90th Percentile
	Benzo(a)anthracene	26	246	ug/kg-WWW	8/9	495	ug/kg-WWW	90th Percentile
	Chrysene	35	284	ug/kg-WWW	9/9	572	ug/kg-WWW	90th Percentile
	Benzo(b)fluoranthene	108	450	ug/kg-WWW	9/9	659	ug/kg-WWW	90th Percentile
	Benzo(k)fluoranthene	44	170	ug/kg-WWW	9/9	211	ug/kg-WWW	90th Percentile
	Total Benzo(a)fluoranthenes	152	620	ug/kg-WWW	9/9	696	ug/kg-WWW	90th Percentile
	Benzo(a)pyrene	69	254	ug/kg-WWW	9/9	307	ug/kg-WWW	90th Percentile
	Indeno(1,2,3-cd)pyrene	20	62	ug/kg-WWW	9/9	92	ug/kg-WWW	90th Percentile
	Dibenz(a,h)anthracene	4.4	18	ug/kg-WWW	9/9	25	ug/kg-WWW	90th Percentile
	Benzo(g,h,i)perylene	20	55	ug/kg-WWW	9/9	75	ug/kg-WWW	90th Percentile
	Total HPAH	500	3399	ug/kg-WWW	9/9	6316	ug/kg-WWW	90th Percentile
	Total BaP Equivalent	90	350	ug/kg-WWW	9/9	432	ug/kg-WWW	90th Percentile
	Aroclor 1016	ND	ND	ug/kg-WWW	0/9	43	ug/kg-WWW	90th Percentile
	Aroclor 1221	ND	ND	ug/kg-WWW	0/9	43	ug/kg-WWW	90th Percentile
	Aroclor 1232	ND	ND	ug/kg-WWW	0/9	43	ug/kg-WWW	90th Percentile
	Aroclor 1242	ND	ND	ug/kg-WWW	0/9	86	ug/kg-WWW	90th Percentile
	Aroclor 1248	ND	ND	ug/kg-WWW	0/9	43	ug/kg-WWW	90th Percentile
	Aroclor 1254	13	44	ug/kg-WWW	8/9	104	ug/kg-WWW	90th Percentile
	Aroclor 1260	14	14	ug/kg-WWW	1/9	45	ug/kg-WWW	90th Percentile
	Total PCB	13	58	ug/kg-WWW	8/9	205	ug/kg-WWW	90th Percentile
	Total 2,3,7,8-TCDD (Equiv.)	0.00016	0.00053	ug/kg-WWW	9/9	0.00825	ug/kg-WWW	90th Percentile

^aBased on 9 composite clam samples from laboratory bioaccumulation study.

^bSite-wide exposure concentration estimated from surface sediment concentrations using biota-sediment accumulation factor.

WW: Wet-weight.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 11—Human Health Cancer Toxicity Data Summary

Pathway: Ingestion of Fish and/or Shellfish

Chemical of Concern	Oral Cancer Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Carbazole	2.00E-02	(mg/kg)/day	B2	HEAST	1997
Total cPAHs (BaP equiv.)	7.30E+00	(mg/kg)/day	B2	IRIS	1997
Total PCBs	2.00E+00	(mg/kg)/day	B2	IRIS	1997
2,3,7,8-TCDD (Equiv.)	1.56E+05	(mg/kg)/day	B2	HEAST	1995

IRIS: Integrated Risk Information System, U.S. EPA.

HEAST: Health Effects Assessment Summary Tables.

B2: Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 12—Human Health Non-Cancer Toxicity Data Summary

Pathway: Ingestion of Fish and/or Shellfish

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ
Acenaphthene	Chronic	6.00E-02	(mg/kg)/day	Liver	3000 ^a	IRIS	1999
Anthracene	Chronic	3.00E-01	(mg/kg)/day	NOEL	3000 ^a	IRIS	1999
Fluoranthene	Chronic	4.00E-02	(mg/kg)/day	Kidney, Liver, Blood	3000 ^a	IRIS	1999
Fluorene	Chronic	4.00E-02	(mg/kg)/day	Blood	3000 ^a	IRIS	1999
Naphthalene	Chronic	4.00E-02	(mg/kg)/day	Not Applicable	Not Applicable	Surrogate ^b	Not Applicable
Pyrene	Chronic	3.00E-02	(mg/kg)/day	Kidney	3000 ^a	IRIS	1997
Total PCBs	Chronic	2.00E-05	(mg/kg)/day	Eye, Impaired Growth, Immune System	3000 ^a	IRIS	1997

^aUncertainty factor; Modifying factor = None; Confidence in value = Low.

^bFluoranthene and fluorene used as surrogate for naphthalene.

IRIS: Integrated Risk Information System, U.S. EPA.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 13—Risk Parameters

Fish and Shellfish Consumption Exposure Scenario Parameters									
Parameter	Parameter Description	Exposure via Fish Consumption				Exposure via Shellfish Consumption			
		Adult RME	Adult CTE	Child RME	Child CTE	Adult RME	Adult CTE	Child RME	Child CTE
c(fish)	concentration of contaminant in fish (ug/kg)	Chemical Specific							
IR	human daily ingestion rate of fish (g/day)	15.96	1.05	0.465	0.465	91.56	8.05	8.61	0.18
EF	human exposure frequency to scenario involving consumption of fish (days/yr)	175	175	175	175	175	175	175	175
ED	human exposure duration to scenario involving consumption of fish (years)	24	24	6	6	24	25	6	6
f(PS)	fraction of fish consumed that are obtained from Puget Sound (unitless)	0.21	0.21	0.21	0.21	0.67	0.67	0.67	0.67
f(species)	fraction of types fish/shellfish species consumed that are available at the site (unitless)	1	1	1	1	0.49	0.34	0.49	0.34
f(utilization)	fraction the site represents of total sites utilized by individuals in Puget Sound to harvest fish/shellfish (unitless)	1	1	1	1	1	1	1	1
BW	body weight of person (kg)	70	70	15	15	70	70	15	15
ATcancer	averaging time over which carcinogenic exposure should be considered—usually considered as a lifetime (years)	70	70	NA	NA	70	70	NA	NA
ATnoncancer	averaging time over which noncarcinogenic exposure should be considered—usually considered as equal to the exposure duration (years)	24	24	6	6	24	24	6	6
RfDo	oral noncancer reference dose considered an exposure threshold (mg/kg-day)	Chemical Specific							
CSFo	oral cancer slope factor expressing carcinogenic toxicity of contaminant (kg-day/mg)	Chemical Specific							
HQ	hazard quotient expressing a ratio of exposure to the reference dose (unitless)	Chemical Specific							
CR	incremental cancer risk expressing probability of developing cancer over a lifetime from given exposure (unitless)	Chemical Specific							
THQ	target hazard quotient—predetermined value not to be exceeded (unitless)	1	1	1	1	1	1	1	1
TCR	target cancer risk—predetermined value not to be exceeded (unitless)	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
CF1	converts chem conc in fish from ug to mg (mg/ug)	1.00E-03	1.00E-03	1.00E-03	1.00E-03	0.001	0.001	0.001	0.001
CF2	converts ingestion rate from g to kg (kg/g)	1.00E-03	1.00E-03	1.00E-03	1.00E-03	0.001	0.001	0.001	0.001
CF3	converts avg time from years to days (days/yr)	365	365	365	365	365	365	365	365

Sediment/Tissue Concentration Parameters			
Parameter	Parameter Description	Fish Value	Shellfish Value
c(sediment)	concentration of contaminant in sediment (ug/kg-DW)	chem spec	chem spec
c(fish)	concentration of contaminant in fish (ug/kg)	chem spec	chem spec
f(lipid)	fraction of lipid in fish (unitless)	0.017	0.0026
BSAF	biota sediment accumulation factor [(ug-contam/g-lipid)/(ug-contam/g-OC)] for transfer of contaminant from sediment to fish	chem spec	chem spec
foc	fraction of organic carbon in the sediment (unitless)	0.0183	0.0183

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 13—Risk Parameters

Equations for calculating risk

$$HQ = \frac{c(\text{fish}) \times IR \times EF \times ED \times f(\text{PS}) \times f(\text{species}) \times f(\text{utiliz}) \times CF1 \times CF2}{BW \times AT_{\text{noncancer}} \times CF3 \times RfDo}$$

$$CR = \frac{c(\text{fish}) \times IR_{\text{twa}} \times EF \times (EDa + EDc) \times f(\text{PS}) \times f(\text{species}) \times f(\text{utiliz}) \times CF1 \times CF2 \times CSFo}{BW_{\text{twa}} \times AT_{\text{cancer}} \times CF3}$$

$$c(\text{fish}) = \frac{c(\text{sed}) \times f(\text{lipid}) \times BSAF}{foc}$$

Equations for calculating risk-based concentrations

$$RBC(\text{fish}) = \frac{THQ \times BW \times AT_{\text{noncancer}} \times CF3 \times RfDo}{IR \times EF \times ED \times f(\text{PS}) \times f(\text{species}) \times f(\text{utiliz}) \times CF1 \times CF2}$$

$$RBC(\text{fish}) = \frac{TCR \times BW_{\text{twa}} \times AT_{\text{cancer}} \times CF3}{IR_{\text{twa}} \times EF \times (EDc + EDa) \times f(\text{PS}) \times f(\text{species}) \times f(\text{utiliz}) \times CF1 \times CF2 \times CSFo}$$

$$RBC(\text{sed}) = \frac{foc \times RBC(\text{fish})}{f(\text{lipid}) \times BSAF}$$

Time-weighted average values over total exposure duration

$$IR_{\text{twa}} = \frac{(IR_{\text{adult}} \times ED_{\text{adult}}) + (IR_{\text{child}} \times ED_{\text{child}})}{(ED_{\text{child}} + ED_{\text{adult}})}$$

$$BW_{\text{twa}} = \frac{(BW_{\text{adult}} \times ED_{\text{adult}}) + (BW_{\text{child}} \times ED_{\text{child}})}{(ED_{\text{child}} + ED_{\text{adult}})}$$

SUMMARY INTAKE FACTORS						
	Fish			Shellfish		
	Cancer	Adult Noncancer	Child Noncancer	Cancer	Adult Noncancer	Child Noncancer
RME	9.41E-09	2.30E-08	3.12E-09	8.57E-08	2.06E-07	9.03E-08
CTE	6.82E-10	1.51E-09	3.12E-09	5.32E-09	1.31E-08	1.31E-09

NOTE: $HQ = (c(\text{fish}) \times SIF) / RfDo$
 $CR = c(\text{fish}) \times SIF \times CSFo$

$RBC(\text{fish}) = (THQ \times RfDo) / SIF$
 $RBC(\text{fish}) = TCR / (SIF \times CSFo)$

INVERSE SUMMARY INTAKE FACTORS						
	Fish			Shellfish		
	Cancer	Adult Noncancer	Child Noncancer	Cancer	Adult Noncancer	Child Noncancer
RME	1.06E+08	4.36E+07	3.20E+08	1.17E+07	4.86E+06	1.11E+07
CTE	1.47E+09	6.62E+08	3.20E+08	1.88E+08	7.64E+07	7.63E+08

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 14—Human Health Risk Characterization Summary - Carcinogens

Scenario Timeframe: Current (Baseline)
Receptor Population: Tribal Fisher (RME)

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Lifetime Carcinogenic Risk from Ingestion
Fish	Fish Fillet	Ingestion	Benzo(g,h,i)perylene	NA
			Phenanthrene	NA
			Pyrene	NA
			Total (BaP) Equivalent	NA
			Benzo(a)anthracene	NA
			Chrysene	NA
			Benzo(b)fluoranthene	NA
			Benzo(k)fluoranthene	NA
			Benzo(a)pyrene	NA
			Indeno(1,2,3-cd)pyrene	NA
			Dibenz(a,h)anthracene	NA
			Total PCBs	2.5E-05
			Total 2,3,7,8-TCDD (Equiv.)	7.6E-05
Shellfish	Clam Whole Body	Ingestion	Benzo(g,h,i)perylene	NA
			Phenanthrene	NA
			Pyrene	NA
			Total (BaP) Equivalent	2.7E-04
			Benzo(a)anthracene	3.1E-05
			Chrysene	3.6E-07
			Benzo(b)fluoranthene	4.1E-05
			Benzo(k)fluoranthene	1.3E-06
			Benzo(a)pyrene	1.9E-04
			Indeno(1,2,3-cd)pyrene	5.8E-06
			Dibenz(a,h)anthracene	1.6E-05
			Total PCBs	3.5E-05
			Total 2,3,7,8-TCDD (Equiv.)	1.1E-04
Fish & Shellfish	Fish Fillet & Clam Whole Body	Ingestion	Benzo(g,h,i)perylene	NA
			Phenanthrene	NA
			Pyrene	NA
			Total (BaP) Equivalent	2.7E-04
			Benzo(a)anthracene	3.1E-05
			Chrysene	3.6E-07
			Benzo(b)fluoranthene	4.1E-05
			Benzo(k)fluoranthene	1.3E-06
			Benzo(a)pyrene	1.9E-04
			Indeno(1,2,3-cd)pyrene	5.8E-06
			Dibenz(a,h)anthracene	1.6E-05
			Total PCBs	6.0E-05
			Total 2,3,7,8-TCDD (Equiv.)	1.9E-04
Total Risk ^a				5E-04

^aIncludes PCBs.

NA: Not available.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 15—Human Health Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current (Baseline)

Receptor Population: Tribal Fisher

Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient	
					Adult	Child
Fish	Fish Fillet	Ingestion	Benzo(g,h,i)perylene	Kidney	NA	NA
			Phenanthrene		NA	NA
			Pyrene		NA	NA
			Total (BaP) Equivalent		NA	NA
			Benzo(a)anthracene		NA	NA
			Chrysene		NA	NA
			Benzo(b)fluoranthene		NA	NA
			Benzo(k)fluoranthene		NA	NA
			Benzo(a)pyrene		NA	NA
			Indeno(1,2,3-cd)pyrene		NA	NA
			Dibenz(a,h)anthracene		NA	NA
			Total PCBs		1.5	0.2
			Total 2,3,7,8-TCDD (Equiv.)		NA	NA
Fish Total Risks					2	0
Shellfish	Clam Whole Body	Ingestion	Benzo(g,h,i)perylene	Kidney	NA	NA
			Phenanthrene		NA	NA
			Pyrene		0.0	0.0
			Total (BaP) Equivalent		NA	NA
			Benzo(a)anthracene		NA	NA
			Chrysene		NA	NA
			Benzo(b)fluoranthene		NA	NA
			Benzo(k)fluoranthene		NA	NA
			Benzo(a)pyrene		NA	NA
			Indeno(1,2,3-cd)pyrene		NA	NA
			Dibenz(a,h)anthracene		NA	NA
			Total PCBs		2.1	0.9
			Total 2,3,7,8-TCDD (Equiv.)		NA	NA
Shellfish Total Risks					2	1
Fish & Shellfish	Fish Fillet & Clam Whole Body	Ingestion	Benzo(g,h,i)perylene	Kidney	NA	NA
			Phenanthrene		NA	NA
			Pyrene		0.0	0.0
			Total (BaP) Equivalent		NA	NA
			Benzo(a)anthracene		NA	NA
			Chrysene		NA	NA
			Benzo(b)fluoranthene		NA	NA
			Benzo(k)fluoranthene		NA	NA
			Benzo(a)pyrene		NA	NA
			Indeno(1,2,3-cd)pyrene		NA	NA
			Dibenz(a,h)anthracene		NA	NA
			Total PCBs		3.6	1.1
			Total 2,3,7,8-TCDD (Equiv.)		NA	NA
Fish and Shellfish Total Risks					4	1

NA: Not available.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 16—Ecological Exposure Pathways of Concern

Exposure Medium	Sensitive Environment Flag (Y or N)	Receptor	Endangered/Threatened Species Flag (Y or N)	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Sediment	N	Benthic Organisms	N	Sediment ingestion, respiration, direct contact with chemicals in sediment	Benthic invertebrate health	<ul style="list-style-type: none"> - Abundance and richness of individual species, major taxonomic groups (crustaceans, molluscs, polychaetes), and total organisms - Community structure evaluation - Swartz's Dominance Index - Toxicity of sediment to amphipods (<i>Ampelisca abdita</i>) - Toxicity of sediment to echinoderm embryos (<i>Dendraster excentricus</i>)
		Shellfish	N	Ingestion of contaminated sediment and prey, respiration, direct contact with chemicals in sediment	Shellfish population health	<ul style="list-style-type: none"> - Toxicity of sediment to clams (<i>Macoma nasuta</i>) - Chemical concentrations of bioaccumulative COCs in whole body clam tissues
		Flat Fish	N	Ingestion of contaminated sediment and prey, respiration, direct contact with chemicals in sediment	Fish population health	<ul style="list-style-type: none"> - Chemical concentrations of bioaccumulative COCs in whole body English sole tissues - Maternal/egg TCDD transfer model

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 17—Occurrence, Distribution and Selection of Ecological Chemicals of Concern in Sediment

Exposure Medium: Sediment (Benthic Invertebrates)

Chemical of Potential Concern	Minimum Conc. (ppb) ^a	Maximum Conc. (ppb) ^a	Mean Conc. (ppb)	Background Conc. (ppb) ^c	Screening Toxicity Value (ppb)	Screening Toxicity Value Source	HQ Value ^d	COC Flag (Y or N)
2,3,7,8-TCDD (Equiv.) ^b	102	11,819	1,523	122	122	Background	96.9	Y
Acenaphthylene ^b	676	82,174	14,617	2,536	66,000	SMS SQS	1.25	Y
Acenaphthene ^b	1,448	766,234	102,255	8,966	16,000	SMS SQS	47.9	Y
Anthracene ^b	4,552	1,900,000	128,367	29,040	220,000	SMS SQS	8.64	Y
Benzo(a)anthracene ^b	11,714	1,891,304	122,502	58,274	110,000	SMS SQS	17.2	Y
Benzo(a)pyrene ^b	12,857	726,087	89,746	52,438	99,000	SMS SQS	7.33	Y
Benzo(b)fluoranthene	129	215,000	5,759	NA	NA	—	—	Y
Benzo(g,h,i)perylene ^b	5,238	177,826	31,747	25,498	31,000	SMS SQS	5.74	Y
Benzo(k)fluoranthene	48	87,900	2,144	NA	NA	—	—	Y
2-Chloronaphthalene ^b	NA	NA	NA	NA	NA	—	—	Y
Chrysene ^b	16,238	1,860,870	169,923	68,981	110,000	SMS SQS	16.9	Y
Dibenz(a,h)anthracene ^b	1,029	79,130	10,558	6,648	12,000	SMS SQS	6.59	Y
Fluoranthene ^b	19,095	8,695,652	476,699	90,845	160,000	SMS SQS	54.3	Y
Fluorene ^b	2,133	760,000	92,271	9,201	23,000	SMS SQS	33.0	Y
Indeno(1,2,3-cd)pyrene ^b	6,190	215,652	36,156	25,804	34,000	SMS SQS	6.34	Y
2-Methylnaphthalene ^b	1,119	646,753	55,424	NA	38,000	SMS SQS	17.0	Y
Naphthalene ^b	3,324	2,818,182	246,084	10,941	99,000	SMS SQS	28.5	Y
Phenanthrene ^b	9,857	3,468,750	292,003	85,936	100,000	SMS SQS	34.7	Y
Pyrene ^b	16,048	6,956,522	553,522	152,635	1,000,000	SMS SQS	6.96	Y
Total Benzofluoranthenes ^b	27,333	1,743,478	214,170	81,415	230,000	SMS SQS	7.6	Y
Total HPAH ^b	117,257	22,346,522	1,705,017	562,539	960,000	SMS SQS	23.3	Y
Total LPAH ^b	21,990	6,988,052	880,561	144,433	370,000	SMS SQS	18.9	Y
Total PCBs ^b	3,923	78,182	19,291	8,721	12,000	SMS SQS	8.96	Y
Dibenzofuran ^b	1,895	800,000	94,762	NA	15,000	SMS SQS	53.3	N
Phenolic Compounds	7.2	6,770	1,199	NA	29 - 670	SMS SQS	10.1	N
Arsenic	4,700	24,000	12,536	NA	57,000	SMS SQS	<1	N
Chromium	9,200	251,000	45,769	NA	260,000	SMS SQS	<1	N
Copper	12,000	410,000	102,116	NA	390,000	SMS SQS	1.05	N
Mercury	20	4,200	464	100	410	SMS SQS	10.2	N
Zinc	35,000	639,000	197,800	NA	410,000	SMS SQS	1.56	N

^aMinimum/maximum detected concentration above the sample quantitation limit (SQL).

^bData normalized to total organic carbon (TOC) content.

^cBased on average of detected values only.

^dHazard quotient (HQ) is defined as Maximum Concentration/Screening Toxicity Value.

ppb: part-per-billion (ug/kg).

NA: Not available.

SMS SQS: Sediment Management Standards Sediment Quality Standard.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 18—Occurrence, Distribution and Selection of Ecological Chemicals of Concern in Shellfish

Exposure Medium: Clam Whole Body Tissue

Chemical of Potential Concern	Minimum Conc. (ppb)*	Maximum Conc. (ppb)*	Mean Conc. (ppb)	Background Conc. (ppb)*	Screening Toxicity Value (ppb)	Screening Toxicity Value Source	HQ Value*	COC Flag (Y or N)
Mercury	ND	ND	—	—	—	—	—	N
Acenaphthylene ^b	1,043	1,680	1,311	13,842	13,842	Background	<1	N
Acenaphthene ^b	1,161	2,080	1,698	13,842	13,842	Background	<1	N
Anthracene ^b	6,478	562,963	74,405	1,947	1,947	Background	289	Y
Benzo(a)anthracene ^b	9,481	79,355	34,504	13,842	13,842	Background	5.73	Y
Benzo(a)pyrene ^b	30,130	81,935	53,702	5,685	5,685	Background	14.4	Y
Benzo(b)fluoranthene ^b	46,957	147,200	90,604	7,816	7,816	Background	18.8	Y
Benzo(g,h,i)perylene ^b	8,778	17,645	12,301	3,053	3,053	Background	5.78	Y
Benzo(k)fluoranthene ^b	19,000	54,839	35,331	2,526	2,526	Background	21.7	Y
2-Chloronaphthalene ^b	ND	ND	—	—	—	Background	—	N
Chrysene ^b	15,222	96,296	41,782	4,711	4,711	Background	20.4	Y
Dibenz(a,h)anthracene ^b	1,913	5,871	3,123	13,842	13,842	Background	<1	N
Fluoranthene ^b	11,870	295,926	99,135	7,790	7,790	Background	38.0	Y
Fluorene ^b	1,710	17,370	6,314	13,842	13,842	Background	1.25	Y
Indeno(1,2,3-cd)pyrene ^b	8,696	19,935	12,717	3,000	3,000	Background	6.65	Y
2-Methylnaphthalene ^b	4,222	4,222	4,222	13,842	13,842	Background	<1	N
Naphthalene ^b	2,593	5,556	3,609	13,842	13,842	Background	<1	N
Phenanthrene ^b	4,783	37,037	10,024	3,789	3,789	Background	9.77	Y
Pyrene ^b	51,304	437,037	177,850	10,790	10,790	Background	40.5	Y
Total Benzofluoranthenes ^b	65,957	200,000	125,935	9,079	9,079	Background	22.0	Y
Total HPAH ^b	217,348	1,145,111	557,217	41,079	41,079	Background	27.9	Y
Total LPAH ^b	12,304	625,963	90,024	4,763	4,763	Background	131	Y
2,3,7,8-TCDD (Equiv.) ^b	0.00069	0.243	0.123	0.0237	0.0237	Background	10.3	Y
Total PCBs ^b	4,815	18,710	9,301	6,842	6,842	Background	2.73	Y

*Minimum/maximum detected concentration above the sample quantitation limit (SQL).

^bData normalized to lipid content.

^cBased on average of detected values only.

^dHazard quotient (HQ) is defined as Maximum Concentration/Screening Toxicity Value.

ppb: part-per-billion (ug/kg).

ND: Not detected above SQL.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 19—Occurrence, Distribution and Selection of Ecological Chemicals of Concern in Fish

Exposure Medium: Fish Whole Body Tissue

Chemical of Potential Concern	Minimum Conc. (ppb)*	Maximum Conc. (ppb)*	Mean Conc. (ppb)	Background Conc. (ppb)*	Screening Toxicity Value (ppb)	Screening Toxicity Value Source	HQ Value*	COC Flag (Y or N)
Mercury	ND	ND	—	—	—	—	—	N
2,3,7,8-TCDD (Equiv.) ^b	0.00081	0.145	0.0287	0.00489	0.00489	Background	29.7	Y
Total PCBs ^c	4,407	13,136	7,230	4,173	4,173	Background	3.15	Y

*Minimum/maximum detected concentration above the sample quantitation limit (SQL).

^bData normalized to lipid content.

^cBased on average.

^dHazard quotient (HQ) is defined as Maximum Concentration/Screening Toxicity Value.

ppb: part-per-billion (ug/kg).

ND: Not detected of SQL.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 20—Alternate Concentration Limits

Constituents of Concern	ACLs (µg/L)		
	Shallow Wells (9 to -6 ft MLLW)	Intermediate Wells (-20 to -40 ft MLLW)	Deep Wells (-75 to -85 ft MLLW)
Naphthalene	>S	7,700	30,000
Acenaphthylene	3,300	700	2,700
Acenaphthene	>S	>S	>S
Fluorene	930	200	790
Phenanthrene	>S	400	1,000
Anthracene	>S	900	>S
Fluoranthene	>S	100	>S
Pyrene	>S	>S	>S
Benzo(a)anthracene	>S	3.0	>S
Chrysene	>S	3.0	>S
Benzo(b)fluoranthene	>S	>S	>S
Benzo(k)fluoranthene	14	3.0	12
Benzo(a)pyrene	>S	3.0	>S
Indeno(1,2,3-cd)pyrene	0.47	0.1	0.39
Dibenzo(a,h)anthracene	>S	>S	>S
Benzo(g,h,i)perylene	0.09	0.016	0.06
Dibenzofuran	880	190	750
Pentachlorophenol	2,300	490	1,900
Zinc	36,000	7,700	30,000

Note:

The calculated concentrations reported in the table do not result in cleanup levels being exceeded at the mudline. Values correspond to the shortest distance to the mudline for the shallow, intermediate and deep zones. "S" indicates that concentrations in excess of the individual constituent solubility level in water are required to exceed cleanup levels at the mudline.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 21—Alternative Summary

Alternative	Cleanup Goal	Institutional Controls	Monitoring	Cap Material Required ² (cubic yards)	Capping Area (square yards)	Dredged Volume (cubic yards)	Disposal Capacity Needed ^{1,2} (cubic yards)	Disposal Facility ²
Alternative 1 No Action	NA	No	No	0	0	0	0	NA
Alternative 2 Dredging	CSL	Yes	Yes	Offshore: 71,000 Shoreline: 24,000 GDZ: 20,000 Total: 115,000	Offshore: 34,000 Shoreline: 16,000 GDZ: 20,000 Total: 70,000	Offshore: 313,000 CMS: 9000 GDZ: 50,000 Total: 372,000	428,000	Nearshore, CAD or newly constructed upland facility
Alternative 3a Capping	SQS	Yes	Yes	Offshore: 740,000 Shoreline: 26,000 GDZ: 20,000 Total: 786,000	Offshore: 426,000 Shoreline: 18,000 GDZ: 20,000 Total: 464,000	Offshore: 0 CMS: 3,500 GDZ: 0 Total: 3,500	4,025	Existing upland facility.
Alternative 3b Capping	CSL	Yes	Yes	Offshore: 328,000 Shoreline: 23,000 GDZ: 20,000 Total: 371,000	Offshore: 193,000 Shoreline: 15,000 GDZ: 20,000 Total: 228,000	Offshore: 0 CMS: 3,500 GDZ: 0 Total: 3,500	4,025	Existing upland facility.
Alternative 4a Fill Area Removal and Capping	SQS	Yes	Yes	Offshore: 531,000 Shoreline: 26,000 GDZ: 20,000 Total: 577,000	Offshore: 318,000 Shoreline: 18,000 GDZ: 20,000 Total: 356,000	Offshore: 328,000 CMS: 3,500 GDZ: 50,000 Total: 381,500	439,000	Nearshore, CAD or newly constructed upland facility
Alternative 4b Fill Area Removal and Capping	CSL	Yes	Yes	Offshore: 119,000 Shoreline: 23,000 GDZ: 20,000 Total: 162,000	Offshore: 82,000 Shoreline: 15,000 GDZ: 20,000 Total: 117,000	Offshore: 220,000 CMS: 3,500 GDZ: 50,000 Total: 273,500	315,000	Nearshore, CAD or newly constructed upland facility

¹ 15% bulking factor

² Disposal methods and capping volumes have been modified slightly from those provided in the FS.

NA: Not Applicable

GDZ: Groundwater Discharge Zone

CMS: Crowley Marine Services

See Figure 4 for depiction of GDZ, CMS and shoreline areas

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 22—Comparison of Dredge Equipment

Dredge Type	Depth Range (feet)	Production Rate per 24-hour day	% Solids by Weight	Resuspension Potential	Material Transport Method	Volume Increase at Disposal Point
Closed Clamshell	0 – 200	500 – 3,500 CY	> 60%	Moderate to high	Barge	15 – 25%
Cutterhead Suction	3 – 90	3,000 – 15,000 CY	10 to 20%	Low to moderate	Pipeline	15 – 25%
High Energy Vortex (Eddy Pump™)	3 – 200	4,000 – 18,000 CY	50 to 60%	Low	Pipeline	15 – 25%
Limited Access Hydraulic	0 – 60	500 – 1,500 CY	10 to 20%	Low to moderate	Pipeline	15- 25%

CY = Cubic Yards

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 23—Estimated Schedule of Available Capping Material

Source Location	Percent Sand	1999	2000	2001	2002	2003	2004	2005
Duwamish River: Upstream of Settling Basin	70-90%	40,000 CY	0	40,000 CY	0	40,000 CY	0	40,000 CY
Duwamish River: Lower Reach	<50%	100,000 CY	0	100,000 CY	0	100,000 CY	0	100,000 CY
Snohomish River: Upper Reach	90%	0	0	0	240,000 CY	0	0	240,000 CY
Snohomish River: Lower Reach	70%	0	0	240,000 CY	0	240,000 CY	0	240,000 CY
Everett Home Port	70% (est.)	0	150,000 CY	0	0	0	0	0
Annual Volume of Sandy Material (excludes lower Duwamish River)		40,000 CY	150,000 CY	280,000 CY	240,000 CY	280,000 CY	0	320,000 CY
Annual Total Volume		140,000 CY	150,000 CY	380,000 CY	240,000 CY	380,000 CY	0	420,000 CY
Cumulative Volume of Sandy Material (excludes lower Duwamish River)		40,000 CY	190,000 CY	470,000 CY	710,000 CY	890,000 CY	890,000 CY	1,210,000 CY
Cumulative Total Volume		140,000 CY	290,000 CY	670,000 CY	910,000 CY	1,290,000 CY	1,290,000 CY	1,710,000 CY

CY = Cubic Yard.

Dredge Material from Upper Snohomish River may not be available until 2002 due to existing commitments.

Available quantities are variable depending on runoff and dredging requirements.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 24—Items To Be Considered—PSR Site Sediment Remediation

Federal, State, and Local Criteria, Advisories and Procedures	Comments
Guidelines developed by the Elliott Bay/Duwamish Restoration Panel	Guidelines for habitat restoration
Puget Sound Water Quality Management Plan	Defines objectives for standards regarding the confined disposal of contaminated sediment
Standards for Confined Disposal of Contaminated Sediments, Washington Department of Ecology (January 1990)	Guidelines for assessing the suitability of dredged material for unconfined disposal relevant to cap material specifications
Federal and State Water Quality Guidance Documents	Contains policy and technical data reviewed and/or used in the development of state sediment management standards
Area of Contamination Interprogram Policy, developed by Washington Department of Ecology	Guidelines for the management of dredged sediment meeting the criteria as a state dangerous waste
Sediment Cleanup Standards Users Manual, Washington State Department of Ecology (December, 1991)	Guidance for implementing the sediment cleanup decision process for contaminated sediments in Washington State
Sediment Source Control Standards Users Manual, Washington State Department of Ecology (June, 1993)	Guidance for implementing the Sediment Source Control Standards
Local Shoreline Master Program	Guidelines for managed development of shorelines to preserve natural resources while protecting public access and navigation.
Sediment Quality Criteria for the Protection of Human Health	Proposes draft sediment quality standards based on risks to humans

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 25—Revised Costs Summary for MSU Remedial Alternatives

Alternative	Remediation Cost	Disposal Method	Disposal Cost*	Mitigation Cost**	Revised Cost
2—Dredge to CSLs	\$6,010,000	Nearshore	\$11,128,000	\$5,250,000	\$22,388,000
	\$6,010,000	CAD	\$7,704,000	—	\$13,714,000
	\$6,010,000	Constructed Upland	\$19,260,000	—	\$25,270,000
3a—Cap to SQS	\$12,520,000	Established Upland	\$619,000	—	\$13,139,000
3b—Cap to CSLs	\$6,440,000	Established Upland	\$619,000	—	\$7,059,000
4a—Dredge/Cap to SQS	\$12,430,000	Nearshore	\$11,414,000	\$5,250,000	\$29,094,000
	\$12,430,000	CAD	\$7,902,000	—	\$20,332,000
	\$12,430,000	Constructed Upland	\$19,755,000	—	\$32,185,000
4b—Dredge/Cap to CSL	\$5,500,000	Nearshore	\$8,190,000	\$4,350,000	\$18,040,000
	\$5,500,000	CAD	\$5,670,000	—	\$11,170,000
	\$5,500,000	Constructed Upland	\$14,175,000	—	\$19,675,000

* CAD and Nearshore costs from FS. Established upland facility costs have been revised.

** Mitigation costs from PSR Responsiveness Summary. Does not include cost of DNR land use.

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 26—Cost Estimate Summary of Alternative 2 - Dredging to CSLs

Year	Capital Cost	O&M Cost			Discount Factor 5%	Present Worth			Total Present Worth
		Cap Maintenance	Cap Monitoring	Dredge Area Monitoring		Cap Maintenance	Cap Monitoring	Dredge Area Monitoring	
0	4,806,000								4,806,000
1		42,600	-		0.952	40,571	-	-	40,571
2		42,600	56,700		0.907	38,639	51,429	-	90,068
3		42,600	-		0.864	36,799	-	-	36,799
4		42,600	56,700		0.823	35,047	46,647	-	81,694
5		42,600	-	44,550	0.784	33,378	-	34,906	68,284
6		42,600	56,700		0.746	31,789	42,310	-	74,099
7		42,600	-		0.711	30,275	-	-	30,275
8		42,600	56,700		0.677	28,833	38,377	-	67,210
9		42,600	-		0.645	27,460	-	-	27,460
10		42,600	56,700	44,550	0.614	26,153	34,809	27,350	88,311
11		42,600	-		0.585	24,907	-	-	24,907
12		42,600	56,700		0.557	23,721	31,573	-	55,294
13		42,600	-		0.530	22,592	-	-	22,592
14		42,600	56,700		0.505	21,516	28,637	-	50,153
15		42,600	-	44,550	0.481	20,491	-	21,429	41,921
16		42,600	56,700		0.458	19,516	25,975	-	45,490
17		42,600	-		0.436	18,586	-	-	18,586
18		42,600	56,700		0.416	17,701	23,560	-	41,261
19		42,600	-		0.396	16,858	-	-	16,858
20		42,600	56,700	44,550	0.377	16,055	21,370	16,790	54,216
21		42,600	-		0.359	15,291	-	-	15,291
22		42,600	56,700		0.342	14,563	19,383	-	33,946
23		42,600	-		0.326	13,869	-	-	13,869
24		42,600	56,700		0.310	13,209	17,581	-	30,790
25		42,600	-	44,550	0.295	12,580	-	13,156	25,736
26		42,600	56,700		0.281	11,981	15,946	-	27,927
27		42,600	-		0.268	11,410	-	-	11,410
28		42,600	56,700		0.255	10,867	14,464	-	25,331
29		42,600	-		0.243	10,350	-	-	10,350
30		42,600	56,700	44,550	0.231	9,857	13,119	10,308	33,284
Total Present Worth Cost									6,010,000

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 27—Cost Estimate Summary of Alternative 3a - Capping to SQS

Year	Capital Cost	O&M Cost		Discount Factor	Present Worth		Total Present Worth
		Cap Maintenance	Cap Monitoring		Cap Maintenance	Monitoring	
0	9,613,000						9,613,000
1		87,000	-	0.952	82,857	-	82,857
2		87,000	208,800	0.907	78,912	189,388	268,299
3		87,000	-	0.864	75,154	-	75,154
4		87,000	208,800	0.823	71,575	171,780	243,355
5		87,000	-	0.784	68,167	-	68,167
6		87,000	208,800	0.746	64,921	155,810	220,731
7		87,000	-	0.711	61,829	-	61,829
8		87,000	208,800	0.677	58,885	141,324	200,209
9		87,000	-	0.645	56,081	-	56,081
10		87,000	208,800	0.614	53,410	128,185	181,596
11		87,000	-	0.585	50,867	-	50,867
12		87,000	208,800	0.557	48,445	116,268	164,713
13		87,000	-	0.530	46,138	-	46,138
14		87,000	208,800	0.505	43,941	105,458	149,399
15		87,000	-	0.481	41,848	-	41,848
16		87,000	208,800	0.458	39,856	95,654	135,509
17		87,000	-	0.436	37,958	-	37,958
18		87,000	208,800	0.416	36,150	86,761	122,911
19		87,000	-	0.396	34,429	-	34,429
20		87,000	208,800	0.377	32,789	78,695	111,484
21		87,000	-	0.359	31,228	-	31,228
22		87,000	208,800	0.342	29,741	71,378	101,119
23		87,000	-	0.326	28,325	-	28,325
24		87,000	208,800	0.310	26,976	64,742	91,718
25		87,000	-	0.295	25,691	-	25,691
26		87,000	208,800	0.281	24,468	58,723	83,191
27		87,000	-	0.268	23,303	-	23,303
28		87,000	208,800	0.255	22,193	53,264	75,457
29		87,000	-	0.243	21,136	-	21,136
30		87,000	208,800	0.231	20,130	48,312	68,441
Total Present Worth Cost							12,520,000

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 28—Modified Alternative 3b - Capping to CSLs

Capital Cost

Description	Unit	Quantity	Unit Cost	Cost
1. Mobilization	LS	1	300,000.00	\$300,000
2. Crowley Marine Terminal Dredging				
Dredge Mobilization	LS	1	15,000.00	\$15,000
Dredging w/Clamshell	Days	10	2,500.00	\$25,000
Short Term Monitoring	Days	5	2,200	\$11,000
3. Groundwater Discharge Area Capping				
A. Cap				
Silty Sand	CY	20,000	3.00	\$60,000
Transport and Placement	CY	20,000	4.25	\$85,000
B. Short-term Monitoring - Capping				
Water Quality Monitoring	LS	1	3,720.00	\$3,720
Bathymetric/Sed. Profile Surveys	LS	1	11,700.00	\$11,700
4. Shoreline Area Capping				
A. Cap				
Silty Sand	CY	23,000	3.00	\$69,000
Transport and Placement	CY	23,000	9.00	\$207,000
B. Short-term Monitoring - Capping				
Water Quality Monitoring	LS	1	38,068.00	\$38,068
Bathymetric/Sed. Profile Surveys	LS	1	11,700.00	\$11,700
5. Non-shoreline Area Capping				
A. Cap				
Silty Sand	CY	328,000	3.00	\$984,000
Transport and Placement	CY	328,000	4.25	\$1,394,000
B. Short-term Monitoring - Capping				
Water Quality Monitoring	LS	1	61,258.00	\$61,258
Bathymetric/Sed. Profile Surveys	LS	1	11,700.00	\$11,700
Subtotal Capital Costs				\$3,288,146
Administrative Cost	% SUBTOTAL	10 *		\$328,815
Engineering Expenses	% SUBTOTAL	15 *		\$493,222
Contingency Allowances	% SUBTOTAL	25 *		\$822,037
Total Capital Costs				\$4,930,000

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 29—Cost Estimate Summary of Alternative 3b - Capping to CSLs

Year	Capital Cost	O&M Cost		Discount Factor	Present Worth		Total Present Worth
		Cap Maintenance	Monitoring		Cap Maintenance	Monitoring	
0	4,930,000						4,930,000
1		41,985	-	0.952	39,986	-	39,986
2		41,985	114,600	0.907	38,082	103,946	142,027
3		41,985	-	0.864	36,268	-	36,268
4		41,985	114,600	0.823	34,541	94,282	128,823
5		41,985	-	0.784	32,896	-	32,896
6		41,985	114,600	0.746	31,330	85,516	116,846
7		41,985	-	0.711	29,838	-	29,838
8		41,985	114,600	0.677	28,417	77,566	105,983
9		41,985	-	0.645	27,064	-	27,064
10		41,985	114,600	0.614	25,775	70,354	96,130
11		41,985	-	0.585	24,548	-	24,548
12		41,985	114,600	0.557	23,379	63,814	87,192
13		41,985	-	0.530	22,266	-	22,266
14		41,985	114,600	0.505	21,205	57,881	79,086
15		41,985	-	0.481	20,196	-	20,196
16		41,985	114,600	0.458	19,234	52,500	71,733
17		41,985	-	0.436	18,318	-	18,318
18		41,985	114,600	0.416	17,446	47,619	65,064
19		41,985	-	0.396	16,615	-	16,615
20		41,985	114,600	0.377	15,824	43,192	59,015
21		41,985	-	0.359	15,070	-	15,070
22		41,985	114,600	0.342	14,353	39,176	53,529
23		41,985	-	0.326	13,669	-	13,669
24		41,985	114,600	0.310	13,018	35,534	48,552
25		41,985	-	0.295	12,398	-	12,398
26		41,985	114,600	0.281	11,808	32,230	44,038
27		41,985	-	0.268	11,246	-	11,246
28		41,985	114,600	0.255	10,710	29,234	39,944
29		41,985	-	0.243	10,200	-	10,200
30		41,985	114,600	0.231	9,714	26,516	36,230
Total Present Worth Cost							6,440,000

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 30—Cost Estimate Summary of Alternative 4a - Fill Removal to SQS and Cap

Year	Capital Cost	O&M Cost			Discount Factor	Present Worth			Total Present Worth
		Cap Maintenance	Cap Monitoring	Dredge Area Monitoring		Cap Maintenance	Cap Monitoring	Dredge Area Monitoring	
0	10,024,000								10,024,000
1		64,600	-		0.952	61,524	-	-	61,524
2		64,600	174,000		0.907	58,594	157,823	-	216,417
3		64,600	-		0.864	55,804	-	-	55,804
4		64,600	174,000		0.823	53,147	143,150	-	196,297
5		64,600	-	38,000	0.784	50,616	-	29,774	80,390
6		64,600	174,000		0.746	48,206	129,841	-	178,047
7		64,600	-		0.711	45,910	-	-	45,910
8		64,600	174,000		0.677	43,724	117,770	-	161,494
9		64,600	-		0.645	41,642	-	-	41,642
10		64,600	174,000	38,000	0.614	39,659	106,821	23,329	169,808
11		64,600	-		0.585	37,770	-	-	37,770
12		64,600	174,000		0.557	35,972	96,890	-	132,861
13		64,600	-		0.530	34,259	-	-	34,259
14		64,600	174,000		0.505	32,627	87,882	-	120,509
15		64,600	-	38,000	0.481	31,074	-	18,279	49,352
16		64,600	174,000		0.458	29,594	79,711	-	109,305
17		64,600	-		0.436	28,185	-	-	28,185
18		64,600	174,000		0.416	26,843	72,301	-	99,143
19		64,600	-		0.396	25,564	-	-	25,564
20		64,600	174,000	38,000	0.377	24,347	65,579	14,322	104,248
21		64,600	-		0.359	23,188	-	-	23,188
22		64,600	174,000		0.342	22,084	59,482	-	81,565
23		64,600	-		0.326	21,032	-	-	21,032
24		64,600	174,000		0.310	20,030	53,952	-	73,982
25		64,600	-	38,000	0.295	19,077	-	11,222	30,298
26		64,600	174,000		0.281	18,168	48,936	-	67,104
27		64,600	-		0.268	17,303	-	-	17,303
28		64,600	174,000		0.255	16,479	44,386	-	60,865
29		64,600	-		0.243	15,694	-	-	15,694
30		64,600	174,000	38,000	0.231	14,947	40,260	8,792	63,999
Total Present Worth Cost									12,430,000

Pacific Sound Resources Record of Decision—Marine Sediments Unit
Table 31—Cost Estimate Summary of Alternative 4b - Fill Removal to CSLs and Cap

Year	Capital Cost	O&M Cost			Discount Factor	Present Worth			Total Present Worth
		Cap Maintenance	Cap Monitoring	Dredge Area Monitoring		Cap Maintenance	Cap Monitoring	Dredge Area Monitoring	
0	4,585,000								4,585,000
1		19,300	-		0.952	18,381	-	-	18,381
2		19,300	67,500		0.907	17,506	61,224	-	78,730
3		19,300	-		0.864	16,672	-	-	16,672
4		19,300	67,500		0.823	15,878	55,532	-	71,411
5		19,300	-	39,100	0.784	15,122	-	30,636	45,758
6		19,300	67,500		0.746	14,402	50,370	-	64,771
7		19,300	-		0.711	13,716	-	-	13,716
8		19,300	67,500		0.677	13,063	45,687	-	58,750
9		19,300	-		0.645	12,441	-	-	12,441
10		19,300	67,500	39,100	0.614	11,849	41,439	24,004	77,292
11		19,300	-		0.585	11,284	-	-	11,284
12		19,300	67,500		0.557	10,747	37,587	-	48,333
13		19,300	-		0.530	10,235	-	-	10,235
14		19,300	67,500		0.505	9,748	34,092	-	43,840
15		19,300	-	39,100	0.481	9,284	-	18,808	28,091
16		19,300	67,500		0.458	8,842	30,923	-	39,764
17		19,300	-		0.436	8,421	-	-	8,421
18		19,300	67,500		0.416	8,020	28,048	-	36,067
19		19,300	-		0.396	7,638	-	-	7,638
20		19,300	67,500	39,100	0.377	7,274	25,440	14,736	47,450
21		19,300	-		0.359	6,928	-	-	6,928
22		19,300	67,500		0.342	6,598	23,075	-	29,673
23		19,300	-		0.326	6,284	-	-	6,284
24		19,300	67,500		0.310	5,984	20,930	-	26,914
25		19,300	-	39,100	0.295	5,699	-	11,546	17,246
26		19,300	67,500		0.281	5,428	18,984	-	24,412
27		19,300	-		0.268	5,169	-	-	5,169
28		19,300	67,500		0.255	4,923	17,219	-	22,142
29		19,300	-		0.243	4,689	-	-	4,689
30		19,300	67,500	39,100	0.231	4,466	15,618	9,047	29,130
Total Present Worth Cost									5,500,000

Table 32: Cost Estimation for Groundwater Monitoring and DNAPL Collection
(Pacific Sound Resources: Record of Decision)

Item	Description	Quantity	Units	Unit Cost (\$)	Total Cost
Capital Costs					
Recovery Well Upgrades	new monuments for 7 wells (installed	7	each	1,000	\$7,000
Monitoring Well Construction	MW-16S; 2"-SS casing with sump	22	foot	100	\$2,200
	MW-16I; 2"-SS casing with sump	54	foot	100	\$5,400
	MW-112; 2"-SS casing with sump	54	foot	100	\$5,400
Equipment Shed	Metal shed on concrete slab w/ garage doors, heating, ventilation, lighting	500	square foot	40	\$20,000
Service Vehicle	3/4-ton pick-up with end lift	1	lump sum	15,000	\$15,000
Miscellaneous Equipment	pumps, secondary containment, tools health and safety, decontamination, etc.	1	lump sum	10,000	\$10,000
Subtotal Capital Cost					\$65,000
Engineering design, overhead and administration		1	lump sum	50,000	\$50,000
Deed restrictions	attorney's fees	1	lump sum	5,000	\$5,000
Total Capital Cost					\$115,000
Annual Operation and Maintenance Cost					
Groundwater Monitoring - Analytical Costs (12-well network + 20% for QA/QC)					
Annual costs years 1-5 (quarterly)	subcontract laboratory	58	each	300 ¹	\$17,400
Annual costs years 6-10 (semiannually)	subcontract laboratory	29	each	300 ¹	\$8,700
Annual costs years 11-30 (annually)	subcontract laboratory	15	each	300 ¹	\$4,500
Groundwater Monitoring - Labor Costs					
Annual costs years 1-5 (quarterly)	sampling and reporting	1	lump sum	24,000 ²	\$24,000
Annual costs years 6-10 (semiannually)	sampling and reporting	1	lump sum	12,000 ²	\$12,000
Annual costs years 11-30 (annually)	sampling and reporting	1	lump sum	6,000 ²	\$6,000
Expendible Materials and Fuel	PPE, sampling, decontamination	1	lump sum	1,500	\$1,500
Well, Equipment and Facility Maintenance		1	lump sum	5,000	\$5,000
DNAPL-to-Energy Recovery Facility	manifesting, shipping and disposal	1	lump sum	4,000	\$4,000
PPE and Miscellaneous Waste Disposal	manifesting, shipping and disposal	1	lump sum	2,000	\$2,000
Present Worth of O&M Cost	8% discount rate				\$370,000
General Project Administration and Overhead (5% of subtotal)					\$18,500
Contingency (10% of subtotal)					\$37,000
Total Present Worth Cost					\$541,000

NOTES:

¹ Unit costs for PAH and dibenzofuran by EPA Method 8310 is \$200.

Unit costs for PCP by EPA Method 8040 is \$100.

² Labor costs for a single sampling round are as follows:

Field Technician	24	hours	45	\$1,080
Chemist (data QA/QC)	8	hours	58	\$464
Staff Hydrogeologist	60	hours	58	\$3,480
CAD Operator	6	hours	45	\$270
Supervisor	8	hours	88	\$704

Total \$6,000

CONCURRENCE

INITIAL	ST	W	CO	SP	MLB
NAME	Thomas	Voytila	Ordine	Kowalski	Gearheard
DATE	9/30/99	9/30/99	9/30/99	9/30/99	9-30-99